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# Evaluation of Planning for Fish & Wildlife

LEVEL II

Beltzville  
Reservoir Project  
April 1981

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)			
Beltzville Dam is located in Carbon County, Pennsylvania, on Pohopoco Creek, approximately 8.4 km (5.2 mi) above its confluence with the Lehigh River. The primary project purposes for the 383 ha (947 ac) lake are flood control and water supply.			
Most of the fish-and-wildlife-related planning for the Beltzville project occurred over the three-year period, 1961-1964. The FWS originally indicated			

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that federal acquisition of an area roughly equivalent to the flooded area, and opening of these lands to public hunting, would recover all project-associated wildlife losses. Later, the FWS indicated that mitigation of damages at Beltzville would require the intense management of 121 ha (300 ac) of project land at a cost of \$5,600 for initial development and \$2,200 O&M annually for a period of five years, for a total five-year cost of \$16,600. The FWS further recommended licensing the 121 ha (300 ac) of project lands to the PGC for wildlife management purposes. These actions were considered necessary to replace the project-related projected loss of 200 man-days of hunting.

The desired project lands were licensed to the PGC for wildlife management; however, development and operation have been totally at state expense. Using the limited resources generated at the Beltzville licensed lands (sharecropping agreements) plus an average annual subsidy of \$14,000 from other sources, the PGC is able to provide many times more hunting use on the Beltzville project lands than existed on the same lands prior to project construction or would be likely to exist in the absence of the project. Current use estimates, though far from perfectly acquired, reflect hunter-use of project lands at around 20,000 trips annually. At no point did the construction agency or project beneficiaries incur additional costs related to losses of wildlife resources associated with the permanent inundation of 384 ha (950 ac) of habitat on Pohopoco Creek.

The prime planning aid relating to fishery resources was prepared by the PFC and FWS in 1964. The report presented angler-use predictions for the proposed lake and recommended nine actions for maximizing fishery values. Contrary to pre-impoundment expectations, carp have not become a nuisance species at Beltzville Lake and the recommended spring water-level reductions have not been necessary. The conservation agencies requested construction of 95 fish attractors as partial replacement of the fish concentrating characteristics of inundated cover as the basin of Beltzville Lake had been cleared of all timber and brush prior to impoundment. Due to additional drawdown and boat safety considerations, the recommendation was later withdrawn. The issue of lake zoning, initially raised by the CE, was accepted in principal in the 1964 report although no specific zoning plan was presented. "No wake" zoning was eventually adopted at Beltzville Lake. The 1964 FWS report accepted the CE's stated plan to maintain a minimum flow release of 35 cfs from Beltzville Lake. Temperature and flow agreements have generally been maintained by the CE's operational staff at the Beltzville project. Temperature and oxygen data clearly document that waters released from Beltzville Lake would have been nearly devoid of oxygen during August, September, and early October had a bottom-draw outlet been installed as the FWS had requested.

Total angler-use of the project was predicted to average 33,000 man-days annually, including insignificant use of the tailrace. It appears likely, if tailwater-use could be added to lake-use (25,285 angler trips), that the FWS's prediction of 33,000 angler-trips would be reasonably accurate. Estimated total harvest during 1979-1980 was less than 48 fish weighing 10.4 kg per ha (20 fish weighing 9 lbs per ac).

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**STUDY TO EVALUATE THE ADEQUACY AND  
PREDICTIVE VALUE OF FISH AND WILDLIFE  
PLANNING RECOMMENDATIONS AT CORPS  
OF ENGINEERS RESERVOIR PROJECTS**

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**INDIVIDUAL RESERVOIR PROJECT EVALUATION REPORTS**

**THE BELTZVILLE LAKE PROJECT**

Conducted for Office, Chief of Engineers, U.S. Army

By Sport Fishing Institute, Washington, D.C.

Under Contract No. DACW31-79-C-0005

## PREFACE

This document was prepared by staff of the Sport Fishing Institute for the U.S. Army Corps of Engineers (CE) under contract number DACW31-79-C-0005. The contract requires the compilation and comparison of pre- and post-construction data treating fish and wildlife for twenty separate CE water development projects. This report presents the findings for one of the twenty individual project evaluations.

Upon completion of the full series of twenty separate studies, a final report will be prepared which will contain an analysis of the validity of the predictive procedures used in fish and wildlife planning, and will contain recommendations for improving the planning process.

This evaluation of the adequacy and accuracy of fish and wildlife planning at the Beltzville Reservoir project in Pennsylvania was aided significantly by the participation and active cooperation of many individuals. Raymond Smith and Joe Devlin, U.S. Army Corps of Engineers personnel located at the Beltzville project provided post-impoundment data of value to the study. Corps personnel in the Philadelphia District Office, including Jeff Radley, Wayne Freed and Vince Hill supplied many useful documents describing both pre-impoundment and post-impoundment conditions. Ed Perry at the State College, Pennsylvania Office of the U.S. Fish and Wildlife Service provided all available pre-construction planning documents.

Post-impoundment follow up data were made available from staff of the

Pennsylvania Game Commission. Nick Vukovich assisted for the Game Commission in the Harrisburg office and Jacob Serfuss, Jr. and David Moyer provided valuable insights during a field tour of the project. Few data were available prior to this study, with regard to post-impoundment fishery conditions at the Beltzville project. A sub-contract study to acquire the necessary data was conducted by the Pennsylvania Fish Commission. The Fish Commission staff members that participated in this effort were Rickalon Hoopes, Craig Billingsley and Del Graff.

Gordon Robertson, Northeast Field Representative with the Wildlife Management Institute accompanied project personnel on a tour of the Beltzville project and reviewed the draft manuscript.

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**SPORT FISHING INSTITUTE**

**PROJECT PERSONNEL**

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**Robert Martin (Project Leader)**

**Richard Stroud (Contractor's Representative)**

**Debra Zambrano (Project Secretary)**

**CONSULTANT'S REVIEW**

Professional terrestrial wildlife consultative services were provided by the staff of the Wildlife Management Institute (WMI). Project personnel were accompanied by a WMI staff specialist during field reconnaissance and on on-site discussions. The terrestrial wildlife portion of the prepared evaluative manuscript was reviewed and evaluated by WMI. All pertinent suggestions offered by the consultant are reflected in this report.

## INTRODUCTION

### Location

Beltzville Dam is located on Pohopoco Creek, 8.4 km (5.2 mi) above the confluence with the Lehigh River, and 5.6 km (3.5 mi) east of Weissport, Pennsylvania. The project site is approximately 97 km (60 mi) north of Philadelphia, Pennsylvania, and is immediately accessible by the Northeast Extension of the Pennsylvania Turnpike. Carbon County, within which the project is located, had a population of 53,183 in 1980.

The Pohopoco Creek drainage basin covers 284 km<sup>2</sup> (111 mi<sup>2</sup>) and the portion located above Beltzville Dam is approximately 242 km<sup>2</sup> (93 mi<sup>2</sup>). The project area is located in the Appalachian Valley and Ridge physiographic province. Soils in the drainage are derived from Mississippian shale and sandstone which yield infertile waters. The mean annual temperature in the basin is about 10 C (50 F) with an average frost free period of 150 days per year. Average annual precipitation was 138.7 cm (54.6 in) over the five-year period of 1974-1978 (1).

### Authorization

The Beltzville project was authorized as a unit of the comprehensive plan for Delaware River Basin water resource development. The comprehensive plan was authorized by Congress in the Flood Control Act of 1962, Public Law 87-874, dated October 23, 1962. The general authorized purposes for the developments were "....for the benefit of navigation and the control of destructive flood water and other purposes...." (2).

#### Physical Features

Beltzville Lake covers 383 ha (947 ac) at recreational pool elevation 191.4 m (628 ft) mean sea level (msl). Elevation 198.4 m (651 ft) msl is the maximum level for the flood control pool, which includes a surface area of 571 ha (1,411 ac).

The U.S. Army Corps of Engineers (CE) owns 1,496 ha (3,695 ac) at the Beltzville Lake project. The Pennsylvania Bureau of Parks (PBP) leases 1,217 ha (3,007 ac) of lands and waters, and 171 ha (422 ac) of lands are leased to the Pennsylvania Game Commission (PGC) for wildlife management purposes. The CE has retained 108 ha (266 ac) for the dam, administration building, and operational appurtenances.

Reservoir storage includes  $0.17 \times 10^7 \text{m}^3$  (1,390 ac-ft) for sediment,  $4.9 \times 10^7 \text{m}^3$  (39,830 ac-ft) for water supply, and  $3.3 \times 10^7 \text{m}^3$  (27,030 ac-ft) for flood control (Table 1). At normal pool the lake is 8.0 km (5.0 mi) in length. The outlet works consist of a control tower and multi-level intake structures. This feature, designed to mix discharge water selectively so as to provide desirable temperature in downstream releases, was the first such facility built by the CE.

#### Descriptive Reports

Pre-construction information related to planning, including formal reports and pertinent correspondence as well as selected references documenting continuing interagency coordination following project construction, were obtained during field visitations to the Ecological Services Branch of the U.S. Fish and Wildlife Service (FWS) at State College,

## INTRODUCTION

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Table 1. - Pertinent physical data for Beltrville project, Carbon County, Pennsylvania

Reservoir	Elevation m	Elevation (ft)	Surface area ha	Storage	
				Capacity $m^3 \times 10^6$	Capacity (ac-ft)
Top of sediment reserve	161.5	(537)	45.7	(113)	1.7
Top of water supply pool	191.4	(628)	383.3	(947)	50.8
Top of flood control pool (spillway crest)	198.4	(651)	570.6	(1,410)	84.2
Maximum spillway design surcharge	203.3	(667.0)	735.3	(1,817)	115.0
Top of dam	204.8	(672.0)	799.7	(1,976)	127.8
Allocated to sediment reserve	150.9-163.7	(495-537)	--	--	1.7
Allocated to supplies of water	163.7-191.4	(537-628)	--	--	49.1
Allocated to flood control	191.4-198.4	(628-651)	--	--	33.3

Source: From reference 2

Pennsylvania and from the CE District office in Philadelphia, Pennsylvania. Project files were also examined at the National Archives in Washington, D.C.

Post-impoundment data were obtained from a variety of sources. Existing wildlife information was gathered from the CE offices both at the project and in Philadelphia. However, most of the somewhat limited wildlife information was supplied by PGC staff at their Harrisburg office and by PGC personnel located at the project. Related use data were provided by PBP personnel at Beltzville.

Information available prior to this evaluation was insufficient to quantify the Beltzville project-related fishery resources. It was necessary to conduct original field studies in order to acquire the data necessary to enable the present planning analysis to proceed. Under terms of the prime contract, a subcontract was awarded to the Pennsylvania Fish Commission (PFC) to conduct angler-use surveys, fish community analyses, and limited water quality studies at the reservoir. The investigations covered the period March 13, 1979 - March 15, 1980. Results were included in a report which was submitted to the prime contractor in July 1980.

## WILDLIFE RESULTS AND DISCUSSION

### Wildlife Resources -- Pre-impoundment Prediction

Initial fish and wildlife planning for the Belitzville project was included in the CE's Delaware River Basin Report published in December of 1960 (3). The FWS's final wildlife impact projections for the 19 projects considered in this comprehensive evaluation were not submitted until May 9, 1961 (4). The FWS's report, treated by the CE as an addendum to Appendix J of the Delaware River Basin Report, contained only reconnaissance-type data and little by way of site-specific impact projections. The magnitude of the project's physical impacts assumed by the FWS in their 1960 report were essentially accurate [417 ha (1,030 ac) reservoir and 560 ha (1,383 ac) of additional fee lands] although design changes were forthcoming from the CE. The FWS concluded that construction of the Belitzville project would result in a \$1,000 per year net increase in wildlife hunting values, from \$17,000 per year to \$18,000 per year, as a result of the simple act of making non-flooded project lands available for hunting. The FWS's basic evaluation concept was described as follows (op.cit.):

In our report, frequent reference is made to the multitudinous factors which presently limit wildlife production and the land available for public hunting. The construction of reservoirs will further reduce wildlife habitat and hunting areas. However, since the water resources development plans for the Delaware Basin include the acquisition of sizeable tracts of land for public use beyond the immediate needs for reservoir construction and operation, the various projects will provide greater hunting opportunities than would otherwise be the case. Properly managed for wildlife and open to public hunting, the "recreational lands" to be acquired adjacent to each of the reservoirs would serve to mitigate

most of the project-caused losses and, in many cases, would also tend to enhance public hunting opportunity as well.

\* \* \* \*

In many instances...the simple act of making the non-flooded project lands available for hunting would mitigate the loss of hunting opportunity resulting from land inundation. In other cases, additional expenditures for wildlife management purposes will be required to mitigate losses. In all cases, however, the usefulness of project lands for hunting can be greatly increased by inclusion of the development measures recommended.

The FWS indicated that the annual wildlife resource value at the Beltzville project could be expected to double to \$36,000 if a \$6,000 annual investment for wildlife features were made as an enhancement measure. Wildlife habitat management on approximately 56 ha (138 ac) was recommended at the Beltzville project in order to realize full development of the project-associated wildlife potential (i.e., \$36,000 annual value). The mechanism, whereby the intensive development and management of 56 ha could result in an additional \$18,000 of hunting recreation annually, was not elucidated. In fact, no data could be located which described the procedures used to develop any of the monetary hunting values reported by the FWS in its 1961 report.

An exchange of several letters occurred between the FWS and the CE during the two-month period following submission of the FWS's May 9, 1961, report (addendum to Appendix J). Thereafter, the FWS submitted a follow-up letter (August 14, 1961) which contained new wildlife-related economic data for eleven (out of nineteen original projects) proposed Delaware River Basin projects, including the Beltzville project. This

follow-up letter indicated that the FWS assumed that both wildlife mitigation and certain enhancement costs were legitimate expenses chargeable either to the Federal Government or to project beneficiaries (5), viz:

Lands recommended for acquisition and development for recreation fall into 2 categories: (1) lands associated with "directly related recreation" and (2) those associated with "indirectly related recreation". The first group would be purchased as a part of project cost. They have been considered as a part of mitigating losses to fish and wildlife resources, provided the necessary initial development and subsequent operation and maintenance are carried out at the expense of the Federal Government or beneficiaries of the major project purposes in accordance with standard reimbursement procedure related to those major purposes. State agencies responsible for administration of fish and wildlife resources would not be expected to pay any part of the cost of mitigating or compensating losses to fish or wildlife resources occurring as a result of project construction.

Lands acquired as a part of project cost for "directly related recreation" would also allow for improvement of fish and wildlife resources, over and above requirements for mitigation. The cost of lands, project modifications (including construction of sub-impoundments), and any costs resulting from modification of project operations in order to bring about improvement and development of fish and wildlife resources represent, we believe, a cost properly chargeable against the project, to be borne by the Federal Government. Interests other than the Federal Government should bear all other development and improvement costs for fish and wildlife and should also pay operation and maintenance costs of fish and wildlife facilities other than any part of the project facilities built to serve jointly both fish and wildlife purposes and other purposes.

The second group of lands, those associated with "indirectly related recreation", were understood to mean recreational lands purchased by private entities in the project area. These lands were not considered as constituting any part in the mitigation process.

New economic data were provided for the Beltzville project (modified from earlier figures as a result of project engineering changes) in the FWS's August 14, 1961, letter (op.cit.). This new presentation listed mitigation requirements of \$5,600 for initial development and \$2,200 for annual operation, maintenance, and repair (OM&R). The enhancement costs were estimated at \$17,600 for initial development, with an annual cost of \$2,600 estimated for OM&R. This combined investment (\$23,200 initial, plus \$4,800 annual OM&R) was expected to provide an annual benefit of \$10,800. No information other than these simple monetary figures were provided.

Two years later, on August 7, 1963, which was nine months following authorization of the Beltzville project by Congress, the CE wrote to the FWS Regional Director, and requested additional planning assistance for fish and wildlife resources at the Beltzville project (6), viz:

It is requested that you indicate the interest your Agency may have in the investigations and studies for the Beltzville Dam & Reservoir. Your views on fish and wildlife requirements are especially desired so they can be correlated with the planning of this office. This information should be furnished by 16 September 1963 so that schedules can be established which will include your findings in the design memorandum presently under preparation.

It should be noted that the FWS report was expected in a little over one month's time (by September 16, 1963). In response, the FWS staff requested additional information from the CE relative to project engineering and land acquisition plans. This letter of December 11, 1963, elicited the following comment by the CE (7), viz:

The limits of the land to be taken in fee for the reservoir

have not been established. However, present criteria establish this limit at 1 to 3 feet above the elevation of the top of the flood control pool, with a minimum taking line, measured 300 feet horizontally from the full flood control pool elevation.

Using the available data, the FWS prepared a draft report and circulated it to the CE and other interested parties on January 20, 1964. On March 2, 1964, in response to the draft, the CE advised the FWS of project engineering changes (changes which were basically final). The CE indicated, however, that the location and extent of wildlife management lands at the project could not, even at that time, be established due to considerations of higher priority uses (8), viz:

In general, we concur with your recommendations. However, the extent of land to be made available for wildlife management cannot be established until the completion of our studies on recreational development. As soon as these studies are completed, this information will be furnished to you.

The FWS's draft report reflected several changes from positions reflected in earlier reports and letters. For example, enhancement of wildlife values (as distinct from mitigation/compensation) was no longer considered a partial project responsibility. To the contrary, the FWS assumed that 100% of the enhancement costs (previously computed to be \$17,600 development costs plus \$2,600 annual OM&R) would have to be borne by local interests (i.e., the PGC). The FWS was also reconsidering their earlier submission that only 56 ha (138 ac) of project land needed to be set aside specifically for wildlife habitat management.

The 1964 draft report contained the identical \$10,800 of net annual wildlife-related benefit value which had appeared in the FWS letter of

August 14, 1961. This circumstance provoked the FWS's Regional Office in Boston, Massachusetts, to prepare the following critique (9), viz:

In order to eliminate some of the confusion that was present in our earlier reports and letters, we plan to state that this report is based on more recent data than was available in the earlier Delaware River Basin reports and letters, and that the evaluations, conclusions, and recommendations in the present report supersede those contained in the previous reports and letters. We will need to clarify the basis for the enhancement benefits of \$10,800. This amount is the equivalent of 5,400 hunter days if a \$2.00 average unit value is used or 3,600 hunter days at a \$3.00 unit value. These figures, according to the statement in the draft, are net. In other words, this pressure is over and above the without-the-project values. Furthermore, this benefit accrues to the 1150 remaining acres (i.e., excluding 300 acres). A pressure of 5,400 and 3,600 hunter days, therefore represents an average increase in annual hunter usage of 4+ and 3+ hunter-days per acre over the entire area. The draft states that inundation of 950 acres will result in a loss of 200 hunter days annually. This is only one hunter day per 4+ acres of bottom land. If it is assumed that this upland area has a without-the-project usage of one hunter day annually per five acres, with-the-project increase amounts to 1200 to 2000 percent, depending upon which of the above pressures is used. Is this a reasonable figure?

The final FWS report, based upon the draft, was released on May 14, 1964 (10). This brief (3-page) document superseded all previous reports and constituted the major FWS input to Belitzville project planning. The document was prepared in cooperation with the PGC.

Pre-construction conditions for specific wildlife populations were identified only in a qualitative way. No specific population densities or cover type data were submitted (op.cit.), viz:

Lands within the project area provide good to excellent habitat for such game species as whitetail deer and cottontail. There are some gray squirrels and ruffed grouse in the wooded portions. Small numbers of pheasants occur naturally, but stocking is necessary to meet the hunting demand. Fur ani-

mals indigenous to the area include red and gray fox, raccoon, mink, muskrat, and skunk. Migratory birds utilizing the area include mourning doves, woodcocks, and several species of waterfowl. Only mourning doves are found in abundance.

The May 14, 1964, report identified project associated impacts in standard terms for the time, i.e., man-days of hunting lost, viz:

Inundation of 950 acres will result in an average loss of 200 man-days of hunting annually for the above species. The lands to be acquired for multiple-use recreation in conjunction with the reservoir development will not materially change the present degree of hunting opportunity on these lands and, therefore, will not mitigate the project-occasioned losses of the wildlife resources. Any losses resulting from closure of portions of the area to hunting due to recreational and operational activities should be offset by benefits derived from having the major portion open to public hunting.

The lands planned for acquisition by the CE above the 384-ha (950-ac) normal pool were reviewed by the FWS and PGC in cooperation with the Pennsylvania Department of Forests and Waters (PDFW). The May 14 report identified a tract of 121 ha (300 ac) as being necessary and best suited for wildlife management purposes to offset the anticipated loss of 200 man-days of hunting, viz:

We have examined the 1,400-acre area planned for acquisition and find that the 300-acre portion outlined in plate I will, if developed for wildlife management, fully replace the project-occasioned losses. In order to accomplish this, a 300-acre tract as shown on plate I should be made available to the Pennsylvania Game Commission for development and management in accordance with a General Plan for Fish and Wildlife Management. Funds for the initial development and for operation and maintenance for the initial five-year period (to insure adequate habitat development) should be provided by the Corps of Engineers as non-reimbursable project costs. These costs are estimated to be \$5,600 for development and \$11,000 for operation and maintenance. We expect that wildlife management will be practiced on other project lands as well as on the 300 acres designated, since such will be necessary in order to provide adequate hunting opportunities

on the project. The Pennsylvania Game Commission has agreed to develop and manage the additional lands.

The Pennsylvania Department of Forests and Waters anticipates developing the recreational aspects of Beltzville Reservoir under agreement with the Federal Government. Lands selected for wildlife mitigation have been coordinated with that Department. Development of these lands for wildlife is expected to complement the recreational program just as recreational developments on remaining project lands should complement wildlife management programs. All lands acquired at the site and not required for project operation or safety or for intensive recreational development will be open to public hunting. Through close coordination among cooperating agencies during project planning, maximum multiple-use development can be assured between operational, recreational, and wildlife interests.

Three specific mitigation recommendations were contained in the May 14, 1964, report, viz:

1. That approximately 300 acres of Federal project land, as shown in plate I, be made available to the Pennsylvania Game Commission in accordance with a General Plan for Fish and Wildlife Management as provided in the Fish and Wildlife Coordination Act.
2. That \$16,600 be provided to the Pennsylvania Game Commission to initially develop and maintain for a period of five years wildlife habitat on the aforementioned 300 acres; these development and maintenance costs to be non-reimbursable project expenditures.
3. That public hunting and wildlife habitat management be permitted, consistent with other purposes of the project, on all Federally-owned lands acquired in conjunction with Beltzville Dam and Reservoir project.

It should be noted that the earlier discussion of possible enhancement of wildlife-related conditions beyond existing levels was not renewed. Furthermore, the troublesome \$10,800 of estimated hunting benefit, related in part to the enhancement possibilities, was also omitted from the final report.

The CE requested more specific information regarding the \$16,600, including detailed descriptions of the features and facilities expected to be provided with the requested funds. The CE was considering developing the necessary facilities themselves. The FWS responded that no detailed plans were available and that the amount of the request was based upon costs incurred at similar projects elsewhere (11). The CE further indicated that they were preparing a recreation plan for the remaining project lands with the intention of turning such completed developments over to the PDFW for administration. This concerned the FWS as they had informal agreements with the PDFW that planning for recreational development at the Beltzville project would be undertaken in concert with the PGC so as to fully consider wildlife values on the recreational lands (12).

The CE's Master Plan, for which the FWS's report was elicited, made no mention of the requested \$16,600 (2), viz:

PRE-OPERATIONAL COORDINATION.

A. Federal Agencies.

(1) U. S. Fish and Wildlife Service. The U. S. Fish and Wildlife Service, in a report on the wildlife resources at the project, dated 14 May 1964, has stated that the acquisition of lands for joint-use and public-use purposes will not change the degree of hunting opportunity now present on those lands. The Service has recommended that 300 acres of project land be set aside for wildlife management under the Pennsylvania Game Commission to mitigate the loss of wildlife habitat.

Examination of agency files during this study revealed no related events of consequence between 1964 and mid-1969. By mid-1969, the CE had

acquired lands needed for the project and construction of the dam and appurtenant structures was under way. Shortly after acquisition, protests by local farmers prompted the CE to initiate some on-the-ground management of agriculturally-valuable lands. This effort did not succeed and the CE turned to the PGC and PDFW for assistance. A meeting was held to activate such management as described in an internal PGC memorandum, as follows (13):

The meeting was...to determine whether there was anything either Department might do to expedite management (get some activity started) on some of the former cropland areas within the reservoir acquisition site. Approximately 300 acres of these cropland areas are designated as mitigation lands for wildlife development and are assigned to the Game Commission, the remainder falling under the jurisdiction of the Department of Forests and Waters for future development.

These lands now lying fallow have been the subject of some local criticism to the Corps--the implication being, that though they have taken the land, they are not doing anything with it. The engineers have attempted to set up an interim lease program with local farmers which has met with no success.

In response, the PGC agreed to begin planning and limited development on the subject lands (op.cit.), viz:

In response to this request and in keeping with our original obligation and intent to manage an assigned area here, our people informed Mr. Campbell [CE Real Estate Division] that the Game Commission would move forward with some preliminary planning activity this summer in cooperation with the Soil Conservation Service. This may include a limited amount of work on the ground such as laying out and plowing in contours, etc., depending upon Soil Conservation Service workload.

The PGC also proposed that a management plan be prepared to guide development of the licensed lands.

A fortuitous development, during the course of the meeting referred to above, led to the preservation of selected buildings on project lands for future use by the PGC in their game management program. This was described in the June 4, 1969, memorandum, viz:

At this meeting, in the course of discussing future development, the matter of overnite storage for our farm equipment was mentioned. Mr. Campbell [CE Real Estate Division] was most cooperative and suggested that we examine several groups of farm buildings not yet demolished. From these, several were selected for our use. Since demolition is imminent, at his suggestion, we have written a letter (with copy to your office) to the Corps of Engineers requesting that these buildings be reserved for our use.

The PDFW's response to the same discussions was to seek authority from the CE to transfer to the PGC immediate but temporary management responsibility for selected croplands within the area proposed for licensing to the PDFW. This proposal was formally submitted by the PDFW on July 2, 1969 (14), viz:

As an alternative to agricultural leasing at this time by the Corps of Engineers, I would suggest a related program which would offer public benefits, yet would maintain the necessary land use flexibility. This would involve a co-operative program with the Pennsylvania Game Commission whereby certain lands within the recreation lease area would be offered to the Commission for management on a temporary basis as an extension of their activities at the reservoir. Some of the Commission's programs are agricultural in nature and could directly benefit the future recreational development. For example, plantings of shrubs and hedgerows for wildlife cover and food would mature into areas suitable for campground development, yearly planting of wildlife food and cover crops in future playfield areas would keep the land clear for turf and other planting and development. Hunting and related forms of activity would, of course, be permitted. The land could be managed by the Commission on a yearly growing-season basis, and thus would be readily available for recreational development wherever funds become available. Informative signs and newspaper releases would bring this program to the attention of the public.

The PGC formally requested a license from the CE for the selected Beltzville project lands on September 24, 1969 (15). A five-year management plan for the requested acreage [identified as including 161 ha (397 ac)] was submitted as required by the CE. The plan identified small game and waterfowl as the target species groups to benefit from the management opportunities afforded by the project. The basic components of the plan were: share-cropping on cropland, with the PGC retaining 25 percent of all crops raised, and establishment of cover strips; limited cutting to benefit wildlife food-producing trees and shrubs in woodland habitat; and establishment of nesting duck and geese populations.

On June 1, 1970, the Pennsylvania Department of Environmental Resources' (formerly Department of Forests and Waters) Bureau of State Parks (PBSP) received a license to use approximately 1,217 ha (3,007 ac) of Beltzville project lands and waters. On January 2, 1971, the PGC received a license to use 141 ha (348 ac). On February 11, 1971, the PGC formally requested authority from the PBSP to include 59 ha (147 ac) of PBSP-licensed lands located contiguously to the PGC lands for wildlife management (16).

The actual area currently under management by the PGC is variously listed in the many related documents, but most frequently identified as including 171 ha (422 ac).

### Wildlife Resources -- Post-impoundment Occurrences

#### Habitat development

Beltzville Dam was closed in February of 1971 and the lake was completely filled by December of the same year. Intensive development of day-use recreational facilities was completed by the CE on both sides of Pine Run Cove, located on the north side of the lake by 1972 (Figure 1). The Pine Run Recreation Area is approximately 81 ha (200 ac) in area. After the initial development of Pine Run by the CE, the PBSP began operating the licensed lands as Beltzville State Park at an average annual cost of \$114,383 (Table 2). Rental of the Park's concession facilities, and sales of launching permits for non-motorized boats has generated an average annual income of only \$2,242 per year.

The undeveloped Beltzville project lands under license to the PBSP were originally planned as intensive day-use and over-night camping facilities. However, this development has never been undertaken by either the CE or the PBSP. Hunting is permitted on 688 ha (1,700 ac) of the undeveloped PBSP licensed lands. There is no specific development or management program for wildlife resources on the undeveloped PBSP lands.

The financial burden of operating Pennsylvania's state parks has forced the PBSP to consider a reduction in their overall program. One possible economy move under consideration (1981) would withdraw PBSP support from Beltzville State Park. Possible ramifications of such action could include assumption of management responsibilities for part or all

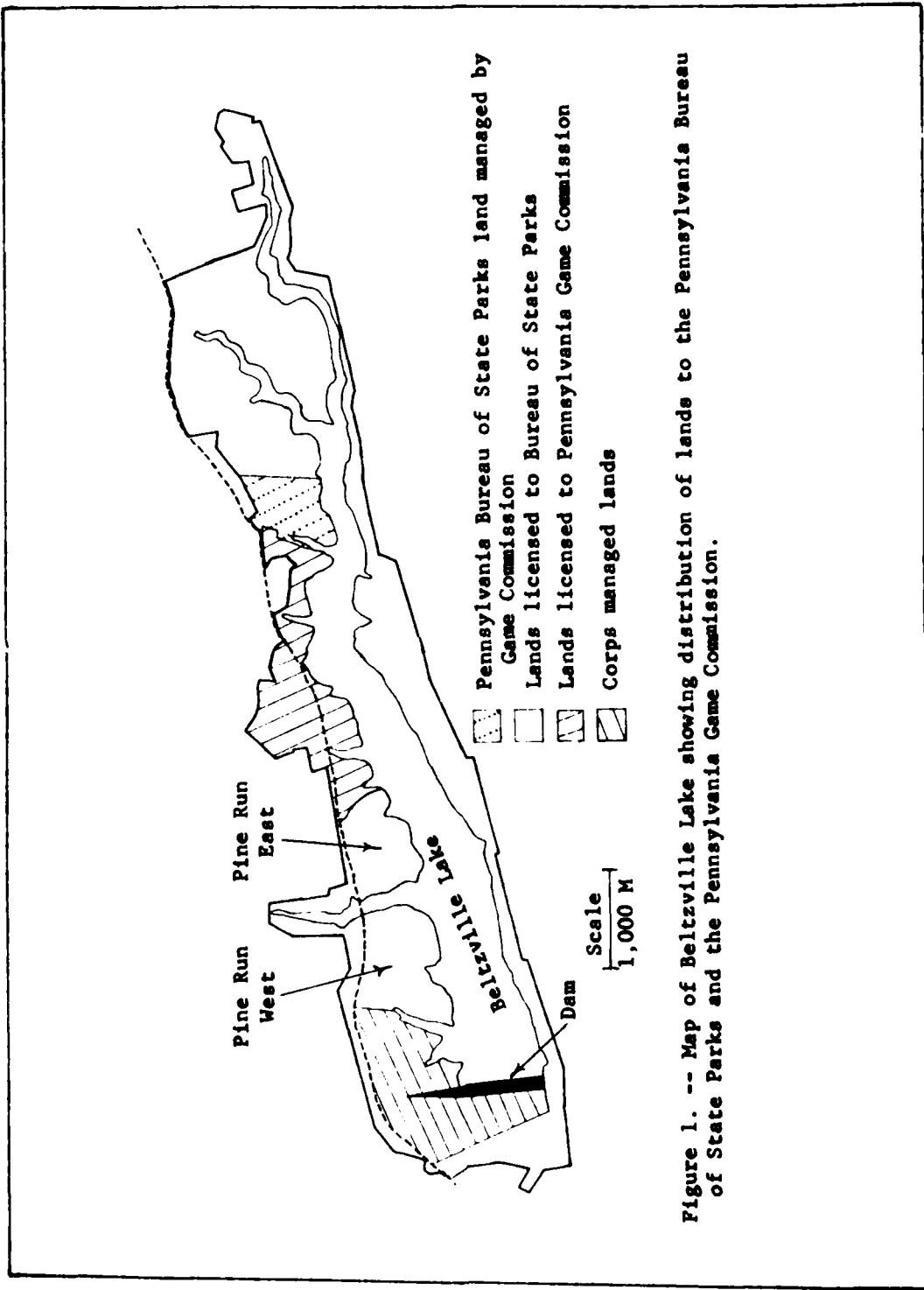


Figure 1. -- Map of Beltzville Lake showing distribution of lands to the Pennsylvania Bureau of State Parks and the Pennsylvania Game Commission.

Table 2. -- Expenditures and income for Beltzville Lake project lands licensed to Pennsylvania Bureau of State Parks, 1973-1978

Category	Years					Averages
	1973	1974	1975	1976	1977	
<b>Expenditures</b>						
Salaries	\$ 27,300	\$ 53,438	\$ 57,525	\$ 71,962	\$ 69,580	\$ 71,556
Wages	26,685	27,361	16,620	24,184	16,400	19,296
Materials & Supplies	25,068	25,584	31,000	31,752	32,700	50,484
Repairs	0	440	2,320	0	5,040	0
<b>Total</b>	<b>\$79,053</b>	<b>\$106,823</b>	<b>\$107,465</b>	<b>\$127,898</b>	<b>\$123,720</b>	<b>\$141,336</b>
<b>Income</b>						
Food concession	\$ 846	\$ 846	\$ 846	\$ 846	\$ 2,207	\$ 2,207
Boat launching permits	1,024	950	952	1,002	874	848
<b>Total</b>	<b>\$ 1,870</b>	<b>\$ 1,796</b>	<b>\$ 1,798</b>	<b>\$ 1,848</b>	<b>\$ 3,081</b>	<b>\$ 3,055</b>
						<b>\$ 2,242</b>

of the undeveloped project lands currently licensed to PBSP by the PGC for the purpose of wildlife management.

Project lands licensed and otherwise managed by the PGC for wildlife purposes were predominately agricultural lands before acquisition for the project. The PGC has continued to farm approximately 40 ha (100 ac) of these lands under sharecropping agreements with local farmers. According to the PGC's management plan, crop production from the leased cropland is shared, with the PGC retaining a one-quarter share of all crops raised (17). The harvested grain is used by the PGC to rear game fowl off the project under game farm conditions. Some 29 ha (70 ac) remain in woodland habitat. The remaining lands are managed mainly in grassland forage and shrub or shrub-conifer cover for various types of upland game. The PGC's plan described management of these areas as follows (op.cit.):

Several areas close to the waterline (but above contour elevation 651 feet) on Tracts 407, 409, 501 and 503 will be managed for waterfowl and small game in grass and occasionally, small grain. Plantings made below elevation 651 feet will be restricted to long term meadow and pasture seedings of grasses and legumes, with oats or other small grain used as a nurse crop for establishing new seedings only. Land within the 628 feet to 651 feet contours will not be used for short term rotations or row crops.

All large agricultural fields including sharecrop areas will be subdivided for the enhancement of wildlife living conditions by the use of shrub, shrub-conifer or conifer cover strips. These strips, using approved, adaptable nursery seeding provided by the Pennsylvania Game Commission nursery, will be planted in varying widths according to terrain and optimum small game habitat requirements. Planting will be done by Pennsylvania Game Commission Land Management personnel.

In addition to planting in approved cover strips in agricultural areas, several conifer plantings will be made on poor soil sites to improve winter cover conditions for wildlife.

In the PGC's original game management layout for the area (Figure 2), fields 2, 4, 7, and 9 were identified as cropland, while tracts 1 and 8 were woodland. Fields 3, 5, and 6 were managed for upland game, and field 10 was designed as a goose pasture.

The PGC has invested a considerable amount of money in the management of the Beltzville licensed lands, primarily as wages and salaries (Table 3). The average annual expenditure over the seven-year period has been \$16,379. Almost \$5,000 have been spent annually, on the average, to stock wildlife in support of hunting.

#### Wildlife communities

Unfortunately, no estimates of individual wildlife populations associated with project lands are available. The CE's Recreation Resource Management Plan (18) did contain a partial list of mammal and resident and migratory bird life that have been identified at the Beltzville project (Table 4).

Observations by local CE and PGC personnel, as related during a tour of project lands, indicate no known use of the project by endangered birds, although one active "birder" did observe a pair of bald eagles at Beltzville on one occasion (Joe Matuska, Palmerton, Pennsylvania, pers. comm., 1981). Use of project lands and waters by nesting waterfowl is minimal. An early PGC plan to close and manage selected bays of the lake for the purpose of waterfowl production was apparently aborted due to opposition

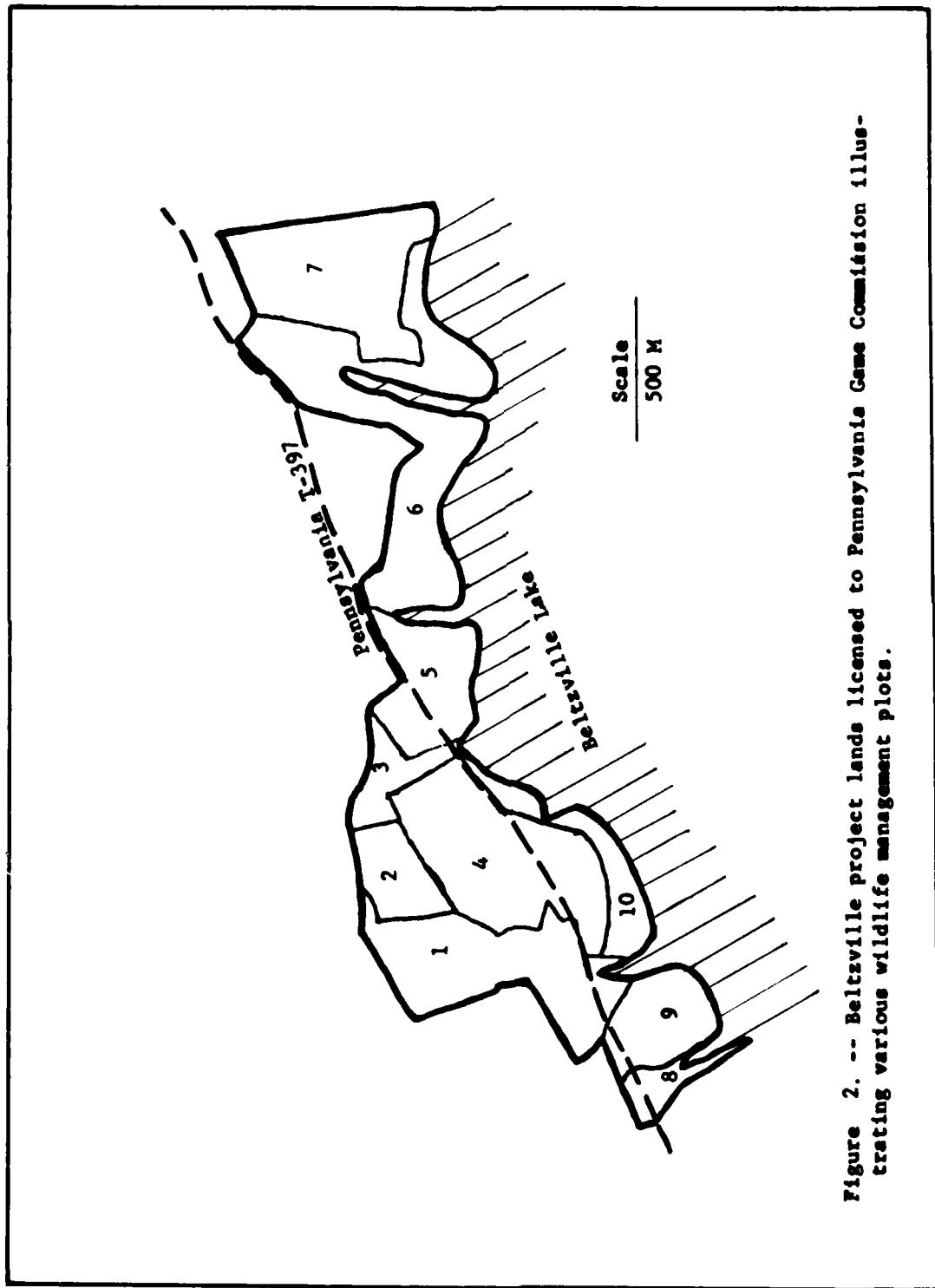


Figure 2. -- Belzville project lands licensed to Pennsylvania Game Commission illustrating various wildlife management plots.

Table 3. -- Operation and maintenance costs incurred by Pennsylvania Game Commission on Belitzville project lands under license

Category	Fiscal year (July 1 - June 30)					Annual average
	1973-74	1974-75	1975-76	1976-77	1977-78	
<b>Operations and maintenance costs</b>						
Salaries and wages	\$10,310	\$10,052	\$12,246	\$13,111	\$7,378	\$8,000
Travel and subsistence	624	--	612	--	722	--
Materials and supplies	1,751	--	100	1,116	126	504
Operation and maintenance (equipment and buildings)	2,565	2,600	--	731	576	--
Value of game stocked	7,552	2,060	3,224	5,465	5,200	4,135
Total expenditures	\$22,802	\$14,732	\$16,182	\$20,423	\$14,002	\$12,639
<b>Income</b>						
Value of grain received from sharecroppers	\$2,781	\$3,552	\$1,316	\$954	\$1,050	\$1,178
						\$1,583
						\$1,773

Table 4. -- Beltzville Lake wildlife inventory

	Scientific name	Common name
Mammals	<u>Castor canadensis</u> <u>Didephis virginianus</u> <u>Euarctos americana</u> <u>Marmota monax</u> <u>Mephitis mephitis (hudsonica)</u> <u>Mustela vison</u> <u>Odocoileus virginianus</u> <u>Ondatra zibethicus</u> <u>Procyon lotor</u> <u>Sciurus carolinensis</u> <u>Sylvilagus floridanus</u> <u>Tamias striatus</u> <u>Tamiasciurus hudsonicus</u> <u>Urocyon cinereoargenteus</u> <u>Vulpes fulva</u>	Beaver Opposum Black bear Woodchuck Striped skunk Mink Whitetail deer Muskrat Raccoon Gray squirrel Cottontail rabbit Chipmunk Red squirrel Gray fox Red fox
Birds	<u>Aix sponsa</u> <u>Anas acuta</u> <u>Anas discors</u> <u>Anas platyrhynchos</u> <u>Anas rubripes</u> <u>Aythya americana</u> <u>Aythya marila</u> <u>Aythya valisineria</u> <u>Bonasa umbellus</u> <u>Branta bernicla</u> <u>Branta canadensis</u> <u>Bubo virginianus</u> <u>Bucephala albeola</u> <u>Bucephala clangula</u> <u>Capella gallinago</u> <u>Chen hyperboreus</u> <u>Clangula hyemalis</u> <u>Colinus virginianus</u> <u>Gallinula chloropus</u> <u>Lophodytes cucullatus</u> <u>Melanitta deglandi</u> <u>Meleagris gallopavo</u> <u>Nyctea scandiaca</u> <u>Otus asio</u> <u>Phasianus colchicus</u> <u>Philohela minor</u> <u>Rallus elegans</u> <u>Rallus limicola</u> <u>Totanus alba</u> <u>Zenaidura macroura</u>	Wood duck Pintail Blue-winged teal Mallard duck Black duck Redhead Greater scaup Canvasback Ruffed grouse Brant Canada goose Great horned owl Bufflehead Common goldeneye Common snipe Snow goose Oldsquaw Bobwhite Common gallinule Hooded merganser White-winged scoter Turkey Snowy owl Screech owl Pheasant American woodcock King rail Virginia rail Barn owl Mourning dove

Source: Reference 19

from the boating fraternity (John Booth, Supervising Game Manager, PGC, pers. comm., 1980).

According to local wildlife law enforcement officers, migratory waterfowl are now more frequently seen to use the project than was the case prior to project construction (David Moyer, Game Protector, PGC, pers. comm., 1980). Furbearers are believed to have suffered adversely as a result of construction of the Beltzville project and the resulting loss of bottomland stream habitat.

Public use

The readily accessible public water and lands of the Beltzville project attract large numbers of recreationists each year. CE estimates of project use have averaged over a half-million visitations annually between 1972 and 1978 (Table 5).

Hunting effort estimates at the Beltzville project are compiled each year by the PBSP staff for those lands licensed to that agency. According to data for the period 1973 through 1979 (Table 6), developed by counting cars (direct observation) and multiplying by 2.5 hunters per car, an average of 5,678 hunting trips have been supported each year on the 688 ha (1,700 ac) of PBSP licensed lands opened to hunting. It is noteworthy that the PBSP estimate of fishermen use for 1979 was 4.5 times higher than an independent angler-estimate developed by the PFC over approximately the same period. The PBSP hunting effort estimate is not considered to be highly dependable. A description of this situation is presented in the fishery section of this report.

Table 5 -- Beltsville Project visitations as reported by U. S. Army Corps of Engineers on Civil Works Recreation-Resource Management System Transcripts, 1972-1978

Year	Month											Total	
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov		
1972	4,527	5,622	8,784	16,039	56,075	56,467	117,789	86,467	18,996	10,930	3,577	1,787	387,060
1973	16,700	36,700	33,600	27,200	31,600	67,100	94,600	71,500	46,500	22,700	6,500	3,000	457,700
1974	5,300	3,000	4,700	29,200	53,300	79,800	146,500	92,200	27,700	19,200	9,500	2,150	472,550
1975	3,239	5,330	6,138	9,876	73,500	99,964	190,420	137,037	29,701	17,693	9,741	4,036	586,675
1976	3,683	5,398	6,141	11,567	91,488	132,878	224,647	134,833	38,985	21,538	13,493	4,466	689,117
1977	2,680	4,100	7,537	15,146	89,475	129,365	274,410	136,025	46,237	24,353	11,272	4,820	745,420
1978	2,019	1,742	2,538	12,281	74,975	96,125	249,485	119,500	35,742	15,505	4,633	2,719	617,264
Average	5,450	8,842	9,920	17,330	67,202	94,528	185,407	111,080	34,837	18,846	8,245	3,283	565,112

Table 6. -- Hunter visitation to Beltsville Lake project lands under license  
to Pennsylvania Bureau of State Parks as compiled from car count data for  
1973-1979

Month	Year					Average		
	1973	1974	1975	1976	1977			
January	141	140	190	175	80	55	110	127
February	20	0	0	0	0	20	0	6
March	6	0	0	0	0	0	0	1
September	120	1	145	0	0	0	0	25
October	428	2,243	2,745	2,605	3,200	2,875	1,245	2,192
November	1,100	2,405	2,470	2,785	2,645	1,925	2,435	2,252
December	365	865	870	870	895	1,450	2,095	1,059
Total	2,180	5,654	6,420	6,435	6,820	6,325	5,910	5,678

During the 1979-1980 fiscal year, the PGC initiated an effort to estimate use on the Beltzville management area. According to the resulting estimate, which was based on observations by PGC personnel, 17,315 hunter-trips were supported on the Beltzville lands under license to the PGC during the survey period. Additionally, there were 1,000 wildlife-observation trips by non-hunters, for a total of 18,315 wildlife-related use visits during the year (Table 7).

The wildlife production of the small acreage under license to the PGC could not, by itself, possibly support all the recreational hunting demands placed on the Beltzville project. To support the full magnitude of hunter interest, the PGC has relied upon a "put-and-take" wildlife stocking program at Beltzville. Wildlife stocking records for the period 1972 through 1979 (Table 8) list ring-neck pheasants and turkey as the most commonly released species. An average of 480 pheasants have been released annually. An ever increasing number of turkeys have been released on project lands since 1976. It should be noted that the PGC terminated the turkey stocking program after 1980, throughout the state. Modest releases of rabbits and quail have also been made in some years with the support of a local rod and gun club.

Table 7. -- Pennsylvania Game Commission (PGC) estimates of wildlife-related public use at PGC licensed Beltzville project lands between July 1, 1979 and June 30, 1980

Target Species	Man-days of use*
Deer	400
Forest game (grouse, squirrel, turkeys, etc.)	1,125
Small game (rabbit, pheasant, squirrel, dove, etc.)	14,200
Waterfowl	600
Furbearers	490
Varmit	500
Total hunting	17,315
Wildlife observations	1,000
Total use	18,315

\* Man-day equivalent to a project visitation.  
Source: Pennsylvania Game Commission LAMP (User estimates, dated 9/22/80)

Table 8 -- Numbers and species of game animals stocked on Beltzville project lands licensed to the Pennsylvania Game Commission 1972-1979

Year	Wildlife planted	
	Species	Numbers
1972	Ring-neck pheasant	400
1973	Ring-neck pheasant	400
	Bobwhite quail	40 (20 pair)
	Rabbit	32 (16 pair)
1974	Ring-neck pheasant	800
	Rabbit	20 (10 pair)*
1975	No information	
1976	Ring-neck pheasant	280
	Turkey	8
1977	Ring-neck pheasant	300
	Turkey	12
1978	Ring-neck pheasant	500
	Turkey	16
1979	Ring-neck pheasant	700
	Turkey	17

\* Stocked by Pohopoco Rod and Gun Club

#### Wildlife Resources -- Discussion of Planning Input

Wildlife-related planning for the Beltzville Lake project covered a relatively short period. The initial FWS input (1960) was drawn from the extensive reconnaissance-level information prepared for all of the water development projects under consideration at that time in the Delaware River Basin. Few specific data were contained in that general discussion. The first site-specific data were contained in the May 9, 1961, addendum to the earlier report. What were essentially the final planning recommendations forthcoming from the FWS for the Beltzville project were contained in their report of May 14, 1964. Therefore, most of the planning effort occurred over the three-year period, 1961-1964.

A number of fundamental changes in position are reflected in the various letters and reports prepared by the FWS throughout this relatively short period. The earliest site-specific FWS report (1961) indicated that federal acquisition of an area around Beltzville Lake roughly equivalent in size to the lands expected to be permanently flooded, and opening of these lands to public hunting, would recover all project-associated wildlife (i.e., hunter-use) losses at the Beltzville project. In fact, a small annual benefit of \$1,000 was projected from such action. Further, the FWS proposed that intense management of a 56-ha (138-ac) area, or one-tenth of the lands expected to be acquired for recreational purposes, would nearly double the with-project wildlife resource value -- from \$519,000 to \$1,028,000 -- over the project life. The proposed intensive management was expected to cost \$6,000 annually

or \$150,000 total. By comparison, the without-project wildlife value in the project area was placed at \$494,000 over a like period.

A mere three months later, the FWS indicated that mitigation of wildlife-associated damages at Beltzville would require special action in the form of an initial investment of \$5,600 and an annual OM&R cost of \$2,200 on a portion of project lands. Therefore, this updated evaluation served to abandon the concept of full mitigation/compensation through simple conversion of land from private to public ownership and opening such lands to public use.

The final FWS report, released in 1964, reiterated this later position, and indicated that the loss of 384 ha (950 ac) to the Beltzville project impoundment would result in a yearly loss of 200 man-days of hunting. To recover the 200 man-days of hunting, the FWS recommended intense management of a 121-ha (300-ac) area of project land at the same costs enunciated in 1961. These costs included \$5,600 for initial development and \$2,200 for annual O&M over a period of five years. Thus, the total five-year cost was projected as \$16,600.

The FWS developed only three mitigation/compensation recommendations during project planning for the Beltzville project, two of which are reflected in the preceding discussion. The first recommendation was to license 121 ha (300 ac) of project lands to the PGC for wildlife management purposes. The second recommendation was for provision at project cost of \$16,600 to pay for the initial development and operational costs for the first five years of the 121-ha tract. The third FWS re-

commendation was that public hunting be allowed on the remaining project lands to the extent consistent with other project purposes.

This rather casual treatment of mitigation issues was highlighted by two later occurrences. The CE developed the recreational facilities at the Pine Run Recreation Area located on the lake's north side, and turned operational responsibilities for the facilities over to the PBSP. A similar approach to the wildlife mitigation features was considered by the CE in 1964. However, when the CE sought specific plans from the conservation agencies, setting forth development features desired for the mitigation lands, no such plans were forthcoming. In fact, the FWS notified the CE that no specific plans had been developed for the requested funding and that the \$16,600 request was based on prior experiences at similar facilities. Another example of the frailties of the wildlife planning process related to the provision of buildings located on project lands to the PGC for storage of equipment needed for management of the mitigatory lands. These accommodations which were eventually provided by the CE, occurred wholly inadvertently as a result of fortuitous remarks made by field staff during an informal, interagency tour of project lands. There had been no coordinated plan or previous request issued by the conservation agencies for these important facilities during the planning phases for Beltzville.

The relatively low priority which the CE's Philadelphia District accorded to wildlife mitigation matters at Beltzville is abundantly evident from the available records. Each time the FWS sought specific land

acquisition or allocation data upon which to base their mitigation recommendations, the development agency responded only in the most general of terms. In fact, the record seems to indicate that the 121-ha (300-ac) tract eventually assigned to wildlife mitigation purposes was allocated as a result of agreements reached during conferences between the two state agencies (PGC and PBSP).

The short lead time provided by the CE for requested FWS planning reports, constitutes yet another reflection of the degree of concern held by the construction agency for wildlife impacts on the Beltzville project. It is certainly fair to assume, however, that the early FWS position -- that full mitigation of the hunting loss at Beltzville could be attained by mere acquisition and opening of project lands to hunting -- influenced the CE's apparent low-priority assessment of the wildlife issues. It remains a matter of record that at no point did the construction agency or project beneficiaries incur additional costs related to losses of wildlife resources associated with the permanent inundation of 384 ha (950 ac) of habitat on Pohopoco Creek.

Records show that the PGC has obtained, on the average, \$1,773 worth of grain annually from sharecroppers using Beltzville project lands. The \$1,773, which is used by the PGC to rear pen-raised game birds, falls far short of putting the PGC's Beltzville management program on a pay-as-you-go basis. However, the PGC is able, using the resources generated at Beltzville, together with an average annual subsidy of \$14,000 from other sources, to provide many times more recreational use on the

Beltzville project lands than existed on the same lands prior to project construction, or would be likely to exist in the absence of the project.

It is reasonably evident from available use-data for the Beltzville project that the readily accessible, public lands surrounding Beltzville Lake attract tremendous numbers of hunters. If, prior to project construction, hunting effort was more or less uniformly distributed over the entire project area, the 200 man-days estimated by the FWS for the 384-ha (950-ac) area of inundation would have represented a without-project hunting effort equivalent to 780 man-days for the entire fee acquisition area of 1,495 ha (3,695 ac). Current use-estimates, though far from perfectly acquired, reflect hunter-use of project lands of perhaps 20,000 trips annually, or approximately 25 times greater than pre-project levels.

The opportunity which has been afforded the PGC at Beltzville to supply an abundance of hunting opportunities was made possible largely through an intensive put-and-take pheasant stocking program. However, use of project lands where wildlife resources are essentially unmanaged (i.e., the largely forested PBSP-licensed lands), provides perhaps 1,000 to 2,000 (estimated by PBSP at 5,680) hunter-trips per year. These data strongly belie the FWS's 1964 contention that public acquisition of private lands, and opening of these lands to public hunting, would fail to provide enhanced hunting opportunity. In this regard, the earlier FWS report of 1961 was significantly more accurate.

An original prime management objective of the PGC for the Belzville lands was the development of new flocks of ducks and geese. It was hoped, by stocking pen-reared waterfowl into protected coves suitable to support nesting, thereby promoting successful reproduction, that the new lake habitat could be used to establish new waterfowl populations. The program would have required some type of zoning of selected small coves to prevent disturbance of these limited areas by intrusion of boats during the waterfowl rearing season. This plan was an unqualified failure, due in large measure to opposition from boating enthusiasts. Their opposition prevented closure of the necessary cove habitat to boat travel. This failure was the direct result of resource allocation decisions favoring project uses that were incompatible with wildlife management objectives.

## FISHERY RESULTS AND DISCUSSION

### Fishery Resources -- Pre-impoundment Predictions

Beltzville Lake was a component of the Delaware River Basin comprehensive development plan. As such, the project was treated in the FWS's comprehensive basin-wide fish and wildlife evaluation report released in 1960 (3). The 1960 report presented reconnaissance-quality data for 21 development projects proposed for the Delaware River Basin. Resource impacts were presented generally as composite gains or losses within general categories of resource types and, as such, were not separable by individual projects. Data therein relating specifically to Beltzville fishery issues were essentially limited to the expected project-associated loss of a stream fishery for trout and to the recommended acquisition of 11 km (6.5 mi) of public fishing rights and development of public facilities along the remaining stream as mitigation.

This major comprehensive report was followed by several addenda in the form of letters which duplicated or clarified data contained in the 1960 report. The first site-specific data provided for the Beltzville project were released by the FWS on May 9, 1961 (4), as an addendum to the comprehensive Delaware River Basin Report. This document indicated that the monetary value of the fishery resources without the project were \$3,000 annually and would be \$7,000 annually with the project, thereby enhancing the value of the resident fishery by \$4,000 annually.

The Flood Control Act of 1962 contained authorization for construction of the Beltzville project for water supply, recreation, and flood control

purposes. In August of 1963 the CE requested specific planning information from the PWS (6), viz:

It is requested that you indicate the interest your Agency may have in the investigations and studies for the Beltzville Dam & Reservoir. Your views on fish and wildlife requirements are especially desired so they can be correlated with the planning of this office. This information should be furnished by 16 September 1963 so that schedules can be established which will include your findings in the design memorandum presently under preparation.

An internal staff report prepared in October of 1963 by PPC personnel contained the following pertinent observations with regard to the stream fisheries of the project locale (19), viz:

It appears that due to the construction of the proposed Beltzville Dam the sportsmen of Pennsylvania are going to lose about seven miles of good trout water. At the present time, Pohopoco Creek is stocked its entire length in Carbon County which is approximately twelve miles and amounts to 101.8 acres. The area to be impounded is the best part of the stream. The remaining areas above and below are of somewhat poorer quality -- the lower area being the poorer of the two.

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In regard to the down stream fishery, if the drawoff of this lake is to be from the bottom, some provisions should be made to acquire the land along the stream down to the Lehigh River and the stream itself should be improved with devices to provide a maximum fishery for the general public. I feel that should a reasonable fishery appear here with a cold water drawoff, private interest would acquire this area and it would be lost to the public.

Should this area be acquired and improved, the devices would have to be of a permanent type to withstand the proposed maximum discharge of 1500 cfs. In regard to the effect the constant minimum discharge would have on the existing fishery in the Lehigh River itself, I doubt that the proposed 35 cfs would have much effect on the mine acid content of the Lehigh in this area. However, this would depend on the amount of acid water that is being brought into the Lehigh River from the four streams which contribute the acid. It is also doubtful that any influence would be felt downstream in the

Allentown - Bethlehem - Easton area by the minimum discharge. However, the maximum discharge may have some effect depending, of course, on existing conditions at the time.

In response to a FWS request for additional descriptive material, the CE provided the following fisheries-related information for the proposed Beltsville project (7), viz:

As requested by Mr. Charles Larsen of your office, the following information is furnished for use in preparation of your report on the fish and wildlife aspects of the Beltsville Dam and Reservoir project.

The minimum flow through the outlet works will be 35 CPS. However, the regulation plan for actual operation will consider providing releases of 50 CPS, or greater, when water is available.

Bottom releases will be provided in the outlet works and will allow complete drawdown of the reservoir. From our experience in other reservoirs, it may be possible to maintain release temperatures of less than 70°F by use of the bottom release.

Present criteria establish the upper limit of clearing in the reservoir at 3 feet above the long-term storage pool level, elevation 623 feet. The lower limit will be determined upon completion of further investigations.

The recreation pool will be at the level of the long-term storage pool, elevation 623 feet, and will be maintained from 15 May until Labor Day. There will be some fluctuation in the elevation of the surface as required by the demand for water supply. For example, there is a 20% probability of there being a 10-ft. fluctuation of the pool surface during this period.

Channelization of Pohopoco Creek downstream of the dam is not proposed because the limiting channel capacity (1,500 CPS) downstream of the dam will accommodate the planned release.

The fourth item, relating to water level fluctuation, became a matter of later concern with regard to the potential installation of fish attraction structures.

The FWS circulated a review draft of their fishery evaluation on June 12, 1964. The draft contained essentially the same information as the final report which was released approximately two months later. The review draft did elicit some enlightening comments from affected agencies, several of which warrant mention.

The CE appeared cautious regarding the oxygen levels that would prevail in Pohopoco Creek below the dam if downstream releases were obtained from a bottom discharge as was planned by the CE at that time. This concern was voiced in a CE letter to the FWS dated June 24, 1964 (20), viz:

Your review draft dated 11 June 1964 on fishery resources at the Beltzville Dam and Reservoir project has been reviewed. There appears to be no conflict of interest between your recommendations and the plans as proposed for this project.

However, it is requested that you indicate in your report the specific need for either multiple-level releases or bottom releases in the outlet works. Previous contacts with your Trenton area office have indicated that bottom releases are sufficient and that multiple releases are not required for oxygen replenishment downstream of the reservoir. From our experience in other reservoirs, the bottom release should maintain release temperatures of less than 70°F.

The FWS responded on July 2, 1964, that bottom releases were, in fact, sufficient to provide the desired temperature water. No mention was made of oxygen requirements (21), viz:

In your letter you requested that we indicate in our report specific needs for either multiple level releases or bottom releases in the outlet works.

It is our understanding that a minimum flow of 35 c.f.s. will be provided at all times and 50 c.f.s. maintained when water is available, and that reservoir releases will be less than 70°F.

Bottom releases would be acceptable to us provided that the

temperature of the released water does not exceed the above temperature (i.e. 70°F).

As was a common occurrence during Beltzville planning, in their response to the FWS draft report, the CE was pressing to meet publication deadlines and requested the final report be submitted in less than six days (20), viz:

I would appreciate receipt of the final report as soon as possible to prevent any delay in the submission of the General Design Memorandum for this project, which is scheduled for 30 June 1964.

The final report differed from the draft only in the respect that the general subject of reservoir zoning was raised. Reservoir zoning was first suggested by the CE. The concept was supported by the PFC although the absence of an enforceable state zoning policy indicated to the PFC that a very general treatment should be used in the FWS report (22), as follows:

Please be advised that the Pennsylvania Fish Commission has not officially adopted a motorboat zoning policy. I would, therefore, suggest you present your report regarding the fisheries resources of the Beltzville Dam, disregarding comments concerning boating. I would imagine that by the time the Beltzville project reaches the construction stage, we may be in a much better position to recommend zoning regulations suitable for all recreational uses.

The FWS's final report was released on September 2, 1964 (23). This brief (four-page) letter-report was based on accurate engineering data, and contained fishery resource impact projections and specific recommendations for mitigation actions at the Beltzville project. No subsequent reports were published; therefore, the 1964 document constituted the primary planning report with regard to the fishery impacts associated with the Beltzville Lake project.

Engineering data assumed by the FWS in the 1964 report included several important features proposed by the CE. The reservoir was expected to cover 383 ha (947 ac) at normal pool and remain stable at this level through the recreational season. The Pohopoco River below the dam was expected to remain unchannelized and to receive a minimum flow of 35 cfs at a temperature not to exceed 21 C (70 F).

The 1964 FWS report stated that, prior to the project, the affected river sections contained both native species and stocked trout, and annually supported an estimated 600 angler-days per river mile, viz:

Without the project the 12 miles of Pohopoco Creek and 1 mile of Pine Run to be affected by the project will provide an annual average of 4,800 man-days of fishing in the 8-mile section of the reservoir site and 3,000 man-days of fishing in the downstream 5-mile segment. The major fish species taken are brown and rainbow trout stocked by the Pennsylvania Fish Commission, with some warmwater species such as small-mouth bass and bullhead providing additional sport.

The report indicated further that, with the project in place and with only minimum facilities, angling use would increase to a level some four times greater than the pre-impoundment use, viz:

With the project the average annual fishery use, with minimum basic facilities, is estimated to be 33,300 fisherman-days having a value of \$50,000. This value assumes development of adequate access to the reservoir site and affected reaches of Pohopoco Creek, and includes an initial minimum of two access areas with boat ramps and parking lots with a total capacity of 150 cars and trailers (plate I). Within ten years, at a rate which would meet the anticipated increase in fishery use, an additional access area would be developed with a boat ramp and parking area for 150 cars and trailers (plate I). It also assumes provision for complete reservoir drawdown, and fishing use of the entire reservoir site at all times in accordance with State law. The fishery in the tailwater section of the Beltzville Dam and Reservoir area is insignificant. However, a huge gravel area exists in this locality that could double as a parking facility for

200 cars or more and provide access for more fishermen than it does now if fishing in this three to four mile tailwater stretch ever picked up (plate I). These parking and access areas should be made available to the Pennsylvania Fish Commission who will be responsible for administering and maintaining these areas.

This discussion does not define a specific period over which the projections were computed. The computation may have embraced a 50-year period of project analysis, which was the customary evaluation period for other projects. Allocation of specific portions of the use prediction (33,300 man-days) between the reservoir and Pohopoco Creek below the dam, is not possible even though use of the tailwater area was described as insignificant.

Two management actions were recommended to enhance the recreational fishery at Beltzville Lake. Each, if successfully implemented, was expected to result in increased angler-use of the lake. The two recommendations were as follows:

Facilities for the continuing control of rough fish species, especially carp, would be desirable. This could, in part, be accomplished through reduction of the pool level at least two feet for a period of three to five days immediately following carp spawning. This operation would serve to destroy spawn through exposure to the air. The timing of this control technique is of extreme importance and should be undertaken when requested by the Pennsylvania Fish Commission. This control would produce an annual benefit of 1,250 fisherman days having a net recreational value of \$1,900.

To concentrate fish for more efficient fisherman utilization, crib-type log shelters should be installed at project cost. One shelter for approximately each 10 surface acres of the long-term storage pool or 95 shelters should be installed. Specific information pertaining to location, placement, and size of log shelters should be determined through coordinated efforts between your staff and the Pennsylvania Fish Commission to facilitate construction during the clearing operations in specified areas. It is estimated that construction

of log shelters would cost about \$9,500. These shelters would produce an annual benefit of 2,200 fisherman-days over the succeeding five years having a net recreational value of \$3,250. These structures will have a long life, and be maintained by the Pennsylvania Fish Commission.

The FWS's 1964 report contained seven additional recommendations to facilitate recreational fishing at the Beltzville project. The complete list of nine recommendations are reproduced below just as presented in the planning report, viz:

1. That operation plans for the reservoir include a provision for annual lowering of the water level about two feet for a period of 3 to 5 days when requested by the Pennsylvania Fish Commission.
2. That during clearing of the reservoir area, provision be made for the construction of 95 log fish shelters for fishery management purposes at project cost.
3. That the project lands and waters required for fishery management purposes be made available to the Pennsylvania Fish Commission under a General Plan for fish and wildlife management in accordance with Section 3 of the Fish and Wildlife Coordination Act.
4. That two access areas with a total capacity of 150 cars and trailers be constructed initially and an additional access area with parking for 150 cars and trailers and a boat ramp be reserved for future development at the reservoir site (plate I).
5. That the existing gravel area located at the tailwater section of the Beltzville Dam and Reservoir (plate I) be made to serve as a parking and access area.
6. That the above parking and access areas be made available to the Pennsylvania Fish Commission who will be responsible for administration and maintenance.
7. That Federal lands and project waters in the project area be open to free use for fishing so long as title to the the lands and structures remains in the Federal Government, except for sections reserved for safety, efficient operation, or protection of public property.

8. That such additional modifications to achieve maximum project benefits be made in project facilities or operations, subsequent to completion of construction, as may be desirable to obtain maximum over-all project benefits, on the basis of follow-up studies by this Bureau to improve or supplement measures taken for the conservation and development of fishery resources.

9. That reservoir zoning regulations for motor boat use be determined jointly by the Pennsylvania Fish Commission, the Pennsylvania Department of Forests and Waters, the Corps of Engineers, and the Bureau of Sports Fisheries and Wildlife and these regulations be included in the Master Plan for this area.

The fish shelter recommendation was later withdrawn as a result of changes in project operational plans which added to the extent of anticipated water supply withdrawals. It may be recalled that in 1963 the CE advised the FWS that water supply withdrawals could cause as much as 3 m (10 ft) of fluctuation in the water level of the lake (7). During telephone conversations of November, 1968, the CE advised PFC fishery staff that updated engineering and operational plans indicated that water levels could fluctuate as much as 4.6 m (15 ft) at Beltzville Lake. The affected PFC field biologist then corresponded directly with the CE to the effect that the fish attractors were no longer feasible (24), viz:

This letter is a confirmation of our telephone conversation of November 6, 1968.

Originally the Pennsylvania Fish Commission had requested the installation of fish attractors in Beltzville Dam in a depth of 10-12 feet of water. Since there may be a 15 foot fluctuation in the recreation pool level this depth could not be used and the devices would have to be located in about 25 feet of water during periods of normal recreation pool level. This would place them in the thermocline and therefore would not be used by the warmwater species for which they were originally requested.

Since they must be located at this depth to remain under at least 4 feet of water during the period of maximum drawdown it is felt that they will not serve a useful purpose, and not be worth the effort or expense of installation.

Also, during a fall drawdown we would prefer that there not be hiding places for the panfish. It is a good management practice to draw lakes down in the fall to drive the panfish out of their hiding places, such as weed beds, and make them available to the predator species.

\* \* \* \*

Therefore, it will be satisfactory with the Pennsylvania Fish Commission if the attraction devices are deleted from Beltzville Dam.

Shortly following the staff letter from the PFC field biologist to the CE, the central PFC office notified the FWS of the letter and supported the position reflected therein.

As a follow-up, the FWS notified the Philadelphia District that the recommended fish attractors were no longer feasible. This letter contained references to anticipated oxygen depletion problems at lower depths, a concern which may have influenced the CE's eventual decision to install multi-level discharge capability at the project rather than the previously agreed bottom-draw facility (25), viz:

This is in reply to your recent request of our Upper Darby field office for reappraisal of the value of fish attractors at the Beltzville Reservoir in light of modifications in project operation. Our conservation and development report on the project dated September 2, 1964 recommended construction of 95 fish attractors to which we attributed fishery benefits specifically related to these facilities. We understand, however, that the project has been modified to include water-supply storage which when released will cause drawdown of the reservoir by about 15 feet at the end of the summer season. A drawdown of this magnitude would necessitate placing the attraction devices at a minimum depth of 19 feet in order to allow a minimum of four feet above the structures for boating safety. Since dissolved

oxygen levels at 19 feet are expected to be inadequate at times for fish due to thermal stratification, fish attractors established at such a depth would not accomplish the objective desired and fishery benefits related to these facilities would be negligible. Therefore, we recommend that fish attractors as specified in our report of September 2, 1964 be deleted from project plans. This will eliminate the fishery benefits credited to these facilities amounting to 2,200 fisherman-days annually with recreation values of \$3,250.

The actual decision to install the outlet tower with multi-level discharge capability for water quality control was reached during a June 1, 1966, meeting of CE staff that involved representatives from the Office of the Chief of Engineers, the North Atlantic Division, as well as the Philadelphia District (26). The decision to provide the multi-level outlet tower followed establishment of a 5.0 ppm dissolved oxygen criterion for the receiving waters. This criterion was set by the U.S. Public Health Service in November, 1964 (27).

The FWS supplied the construction agency with minimum flow requirements considered necessary to support aquatic life in Pohopoco Creek below the dam site during the construction of the outlet works. These data were provided in 1969, in response to a request from CE staff and were stated as follows (28), viz:

Minimum instantaneous flows required to prevent damages to fishery resources in Pohopoco Creek downstream from Beltzville Dam during July and August for a period of 7 days or less are estimated at 35 cfs; minimum flows for periods exceeding 7 days are estimated at 50 cfs.

I also emphasized that specific measures should be included in all construction contracts for the project to preclude sedimentation and excessive turbidities of the stream as a result of construction activities. Mr. Corrigan assured me that the contracts will contain adequate measures to meet the above requirements.

It is noteworthy that, in the cited exchange of 1969, the FWS indicated that minimum flows of 50 cfs would be required to maintain a healthy fishery throughout summer periods of low flow exceeding seven days duration. Earlier FWS planning reports had accepted, without objection, the CE's planned minimum operational release of 35 cfs even though reference to seasonality or duration was lacking.

Construction of the Belzville project was completed in February, 1971, and the lake was impounded during the following ten months.

#### Fishery Resources -- Post-impoundment Occurrences

Data needed to describe the Beltzville recreational fishery in a quantitative sense were not available prior to the current evaluation. A one-year study of the lake fishery was conducted by the PFC to acquire the necessary information upon which to base a reasoned appraisal of the adequacy of the pre-construction planning documents. This study was conducted from March 13, 1979, through March 15, 1980, under subcontract to SFI. Specific study goals included an analysis of the fish community, identification of critical water quality characteristics of the reservoir and a survey of angler-use and harvest. The completion report for the study, submitted to SFI in July, 1980, comprised the primary informational source upon which the following section is based (29).

#### Water quality studies

Selected water quality parameters of the Beltzville pool are routinely measured by the CE on a two to three week schedule beginning generally in May and extending into November. Dissolved oxygen and temperature measurements are taken at predetermined intervals from lake surface to lake bottom at four sampling stations on the lake. The data typically reflect a summer-time oxygen depletion (less than 5.0 ppm) in water deeper than approximately 9 m (30 ft). Oxygen levels frequently dropped as low as 1.0 ppm or less during late summer in the lower 9 m (30 ft) of depth, as measured near the dam (Figure 3) where the lake is approximately 40 m (130 ft) deep.

Temperatures of the lake discharge, as recorded in CE files, generally

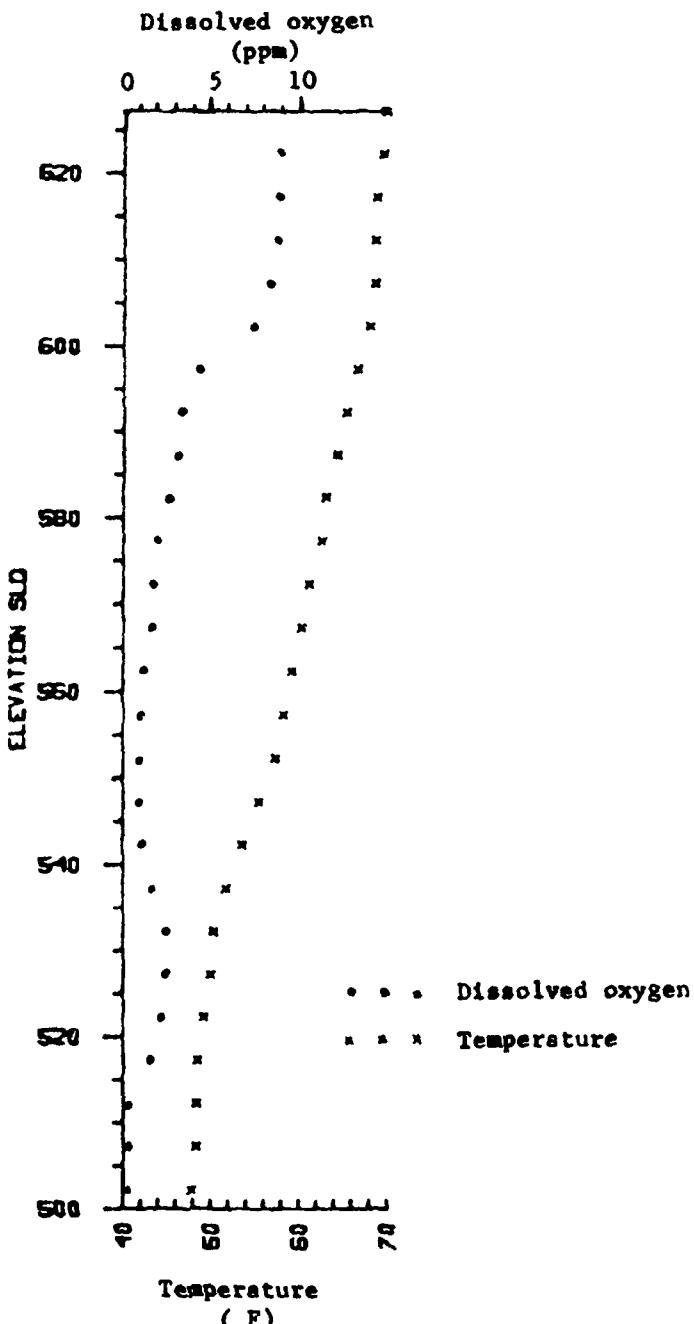


Figure 3. -- Dissolved oxygen and temperature profiles measured in Beltzville Lake near dam in early September (day 253), 1975.

ranged between 10-16 C (50-60 F) although temperatures as high as 18 C (65 F) were recorded in July of 1979. The average yearly maximum temperature of the discharge over the seven years covered by the CE's routine sampling data (1974-1980) was 17 C (63 F).

The PFC conducted limited water quality testing in August, 1979, as part of their contractual investigation for purposes of this evaluation. Temperature and oxygen profile data gathered by the PFC in August compared favorably with the more intensive sampling conducted by the CE as described above. Several other water quality parameters were measured during the PFC's August sampling, viz:

Water Quality.

Water quality varied slightly with sample location. Specific conductance was 18 micromhos in the Wild Creek bay and 45, 49, 39 and 47 micromhos at the tower, mid-lake, Pine Creek and Pohopoco bays respectively. Secchi disc readings were 4.5, 4.0, 3.7, 4.1 and 3.0 meters at the tower, mid-lake, Pine Creek bay, Wild Creek bay and Pohopoco Creek respectively. In all profiles pH varied from the low 6's near to bottom to high 6's near the surface. Methyl orange alkalinity variation from 1-9 mg/l was also similar in all profiles; as was the variation in total hardness from 6-24 mg/l.

Water level fluctuation

Monthly water level fluctuation data reflect that Beltzville Lake has been relatively stable through the peak summer use period; monthly changes rarely exceed 0.6 m (2 ft) during June, July, and August (Table 9). Water level fluctuations in May have been slightly higher, averaging 0.8 m (2.5 ft). The period of greatest storage and water level fluctuation have been the winter and early spring period, Decem-

**Table 9. -- Monthly water level fluctuation of pool elevation in feet above mean sea level at Beltsville Lake. (1973-1980)**

Month	Years								Monthly average
	1973	1974	1975	1976	1977	1978	1979	1980	
<b>Jan</b>									
Max	629.2	629.2	629.2	636.2	628.6	631.7	632.8	628.4	630.7
Min	626.9	627.7	627.6	627.2	626.9	625.2	625.8	627.4	626.8
Avg	628.2	628.3	628.2	628.8	627.7	628.6	627.7	627.7	628.2
Fluc	0.3	1.5	1.6	9.0	1.7	6.5	7.0	1.0	3.9
<b>Feb</b>									
Max	630.3	629.2	631.7	634.0	628.0	628.6	631.4	627.5	630.1
Min	627.6	627.0	627.4	626.2	625.2	623.6	625.6	627.4	626.3
Avg	628.3	628.0	628.5	628.6	626.4	624.5	626.9	627.5	627.3
Fluc	2.7	2.2	4.3	7.8	2.8	5.0	5.8	0.1	3.8
<b>March</b>									
Max	629.1	628.8	631.1	627.5	633.9	635.1	630.0	632.4	631.0
Min	627.7	627.0	627.2	626.8	628.5	623.8	626.2	627.2	626.9
Avg	628.0	628.2	628.4	627.1	631.0	627.2	627.2	628.6	628.2
Fluc	1.4	0.8	3.9	0.7	5.4	11.3	3.8	5.2	4.1
<b>April</b>									
Max	630.6	629.8	629.8	628.8	631.9	634.7	628.7	630.9	630.7
Min	627.8	626.7	627.7	627.4	627.0	626.2	626.1	627.4	627.0
Avg	628.7	628.0	628.3	627.8	629.1	629.5	627.1	628.7	628.4
Fluc	2.8	3.1	2.1	1.4	4.9	8.5	2.6	3.5	3.7
<b>May</b>									
Max	630.1	629.8	629.3	629.3	628.5	633.7	631.2	628.5	630.1
Min	628.0	627.5	627.6	627.4	627.6	627.9	627.8	627.1	627.6
Avg	628.9	628.3	628.3	628.4	628.0	629.8	628.7	627.8	628.5
Fluc	2.1	2.3	1.7	1.9	0.9	5.8	3.4	1.4	2.5
<b>June</b>									
Max	630.7	628.3	629.9	629.1	628.0	629.0	629.2	628.2	629.1
Min	627.8	627.7	627.6	627.5	627.0	627.8	627.5	627.5	627.6
Avg	628.1	627.9	628.1	628.1	627.8	628.2	628.0	627.9	628.0
Fluc	2.9	0.6	2.3	1.6	0.4	1.2	1.7	0.7	1.5
<b>July</b>									
Max	635.1	628.2	630.4	628.6	627.9	628.1	628.4	627.5	629.3
Min	627.9	627.6	627.4	627.5	627.2	627.6	627.7	626.9	627.5
Avg	629.4	627.9	628.4	628.0	627.7	627.9	628.0	627.3	628.1
Fluc	7.2	0.6	3.0	1.1	0.7	0.5	0.7	0.6	1.8
<b>Aug</b>									
Max	629.4	629.5	628.3	629.7	627.1	630.3	628.2	626.9	628.7
Min	627.7	628.0	627.6	628.0	626.4	627.7	627.3	623.2	627.0
Avg	628.0	628.6	627.8	628.8	626.9	628.6	627.6	626.1	627.8
Fluc	1.7	1.5	0.7	1.7	0.7	2.6	0.9	3.7	1.7
<b>Sept</b>									
Max	628.3	629.3	629.0	628.2	626.4	627.8	628.2	627.7	628.1
Min	627.8	627.8	627.0	627.6	623.2	627.3	625.7	613.1	624.9
Avg	628.1	628.2	627.5	627.9	624.9	627.6	626.9	617.3	626.1
Fluc	0.5	1.5	2.0	0.6	3.2	0.5	2.5	14.6	3.2
<b>Oct</b>									
Max	628.2	628.7	631.6	631.0	630.9	627.2	631.3	--	629.8
Min	621.5	627.8	626.7	628.2	625.1	626.5	627.5	--	626.2
Avg	622.4	628.1	628.0	629.5	628.4	626.9	628.6	--	627.4
Fluc	6.7	0.9	4.9	1.8	5.8	0.7	3.8	--	3.6
<b>Nov</b>									
Max	623.5	628.1	629.6	628.0	629.9	626.5	629.8	--	627.9
Min	621.8	627.9	627.5	622.3	627.2	219.5	627.5	--	624.8
Avg	622.6	628.0	628.2	624.1	628.5	621.2	628.1	--	625.8
Fluc	1.7	0.2	2.1	5.7	2.7	7.0	2.3	--	3.1
<b>Dec</b>									
Max	634.0	631.1	628.7	628.8	631.1	626.2	628.4	--	629.8
Min	622.7	628.0	627.6	623.2	627.4	620.7	627.3	--	625.3
Avg	628.5	628.5	627.9	626.3	629.4	624.0	627.7	--	627.5
Fluc	11.3	3.1	1.1	5.6	3.7	5.5	1.1	--	4.5

Source: From CE's Gate Operation Log, Beltsville Lake

ber through April. The tabular elevation-area relationships (Table 10) were used to convert the elevational data (Table 9) to surface area. These data indicate that the minimum spring surface area (April, May, and June) has averaged 379 ha (938 ac), or only 1 percent below normal pool. In fact, the minimum area recorded during the period April through July was in April of 1979 when the surface of Beltzville Lake was reduced to 371 ha (917 ac).

Minimum releases to Pohopoco Creek

The CE's gate operation logs (30) contain gage height data recorded at the U.S. Geological Survey's (USGS) gaging station (No. 01449800) located at Parryville on Pohopoco Creek below Beltzville Dam. The gage height data was used to calculate flow in cfs using the USGS's rating table for the Parryville gage. Minimum flows recorded for each month from January, 1973, to September, 1980, are provided in Table 11. Recorded flows below 35 cfs, the agreed minimum release from Beltzville, occurred on a total of 38 days during the nearly 8-year period of record. After September 16, 1974, flows were allowed to drop below 27 cfs on only 2 occasions. These low flow periods were associated with tower inspections and extended for periods of less than 3 hours.

Flows of less than 50 cfs occurred during parts of July and/or August in every year except 1975, 1976, and 1980. The deficiencies were not normally serious. The most serious summer deficiencies were those of late August, 1979, when a release of only 31 cfs was maintained from August 24 through September 4, a period of 12 days.

Table 10. -- Elevation-area table, Beltzville Lake,  
Pennsylvania

Elevation (msl)*		Surface area	
M	(Ft)	Ha	(Ac)
186.8	(613)	289	(714)
187.1	(614)	295	(729)
187.4	(615)	301	(743)
187.8	(616)	306	(757)
188.1	(617)	312	(772)
188.4	(618)	318	(787)
188.7	(619)	325	(802)
189.0	(620)	331	(818)
189.3	(621)	338	(834)
189.6	(622)	344	(850)
189.9	(623)	350	(866)
190.2	(624)	357	(882)
190.5	(625)	364	(899)
190.8	(626)	370	(915)
191.1	(627)	377	(931)
191.4	(628)	383	(947)
191.7	(629)	390	(964)
192.0	(630)	397	(981)
192.3	(631)	405	(1000)
192.6	(632)	413	(1020)
192.9	(633)	422	(1042)
193.2	(634)	431	(1064)
193.5	(635)	441	(1089)
193.9	(636)	446	(1103)
194.2	(637)	454	(1123)

\* (msl) - Mean sea level

Source: Philadelphia District, CE

Table 11. -- Minimum monthly stream flows (cfs) in Pohopoco Creek below Beltzville Dam at the U.S. Geological Survey's gaging station at Parryville, Pennsylvania

Years	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1973	3	108	12	42	68	42	42	7*	65	65	61	61
1974	63	113	202	149	94	65	40	40	3*	63	65	67
1975	111	113	145	139	111	89	119	76	58	91	108	89
1976	58	167	135	99	31	50	52	7*	52	81	105	50
1977	79	50	108	163	61	43	43	50	50	52	142	316
1978	50	76	76	79	102	94	47	47	47	52	31	27
1979	125	67	207	128	135	65	21	31	135	94	125	-
1980	67	67	56	19*	99	52	52	50	48	-	-	-

\* Gates closed for repair; low flow condition extended for a period of 1 to 3 hours.  
Source: From CE's Gate Operation Log, Beltzville Lake.

#### Fish introductions

After impoundment of Beltzville Lake, water temperature and dissolved oxygen profiles indicated the availability of suitable habitat at various water depths for many fish species having widely different habitat requirements. As a result, 15 different species have been stocked at Beltzville Lake by the PFC (Table 12). All but one of the introduced species were game fish. Of the 14 game-fish species that have been stocked, examples of only 8 species were captured by anglers during the 1979-1980 creel survey. Representatives of two additional stocked species were captured during PFC sampling. Of the four stocked game species not sampled during 1979-80, one (kokanee) was last planted in 1974, while two others (brook trout and coho salmon) were last stocked in 1975. Lake trout have been stocked each year since 1976 but none were recovered during the 1979-80 study.

#### Fish community studies

The Beltzville fish community was investigated with the use of electro-fishing gear, trap nets and gill nets. Sampling was done in the spring, directed at populations congregated for spawning purposes. Fishes collected were identified, weighed, and measured. Scale samples were collected to permit calculation of growth rates.

An effort was also made to estimate the number of harvestable-size game fish in the lake. The population estimation procedures were described in the PFC's 1980 report as follows:

Game fish longer than the legal or desirable size were tagged with a modified Carlin dart tag. The spawning walleye popu-

Table 12. -- Stocking records for Belzville Reservoir; k = thousands, m = millions, F = fingerling, f = fry

Species	Years stocked						
	1970	1971	1972	1973	1974	1975	1976
Brown trout	19 kF		120 kF		9.1 kF		50 kF
Rainbow trout			122 kF				130 kF
Brook trout				37 kF			
Lake trout					6 kF	7.7 kF	8 kF
Kokane salmon		10 kF		7 kF			
Coho salmon					4.5 kF		
Largemouth bass	115 kf				5 kF		
Smallmouth bass				3.7 kF			4.5 kF
Black crappie			5 kF				
Tiger muskellunge	100 kF	1.9 kF	34 kf	2.8 kF	3 kF	1.9 kf	2.8 kF
Chain pickerel	66 kf		5 kf	1.1 kf			
Walleye		1.7 mf			2.4 mf		3.8 mf
Yellow perch			20 mP				
Channel catfish		30 mf		4.4 mf.			
Rainbow smelt						m eggs	m eggs
						m eggs	m eggs

Source: From reference 29

lation was estimated using a Schnabel-type estimation. The largemouth bass population longer than 308 mm (12 inches) was estimated using the Petersen method and tag returns from Carbon County B.A.S.S. tournament on June 10, 1979. Population estimates for other species were obtained from total angler harvest of that species and tag returns from fish caught. Because of the low number of fish in these samples, the Chapman modification of the Petersen formula was used to estimate population size.

Electrofishing and netting at Beltzville yielded samples of 23 species of fish (Table 13). Sixteen species of game fish were sampled. Use of electrofishing gear captured specimens of 13 of the 16 game-fish species. Trap nets captured specimens of 9 game fish species and gill nets sampled 7 game species. Trap nets were highly selective for brown bullhead and yellow perch. Walleyes were collected with all sampling gear as were tiger muskellunge and black crappies (one specimen by each gear type). The most abundantly represented species in the collections were brown bullheads (372), walleyes (182), and yellow perch (154).

The relatively small overall number of fish captured during the sampling indicated low population densities according to the PFC investigations, viz:

The capture of only 829 individual fish during 2,160 hours of trapnetting, 80 hours of experimental gillnetting, and 56 hours of electrofishing in March/April and June suggest that fish populations are quite low. The large channel catfish capture[d] may represent survivors of the 1971 fry and 1972 fingerling introductions. There was no documentation of successful reproduction of walleye during the sampling, but a spawning aggregation was fished in March and April.

Estimates of density were made for several of the fish species, as determined from the eventual harvest of fish tagged and released during the earlier sampling phase of the study (Table 14). Although 267 fish

Table 13. -- Fish species collected, and method of capture for Belzville Lake sampling,  
March/April and June, 1979

Common name	Scientific name	No. caught		
		Trap nets	Gill nets	Electrofishing
Rainbow trout	<u>Salmo gairdneri</u>	--	--	2
Brown trout	<u>Salmo trutta</u>	--	4	3
Palomino trout	<u>Salmo hybrid</u>	1	--	--
Chain pickerel	<u>Esox niger</u>	6	--	3
Tiger muskellunge	<u>Esox masquinongy x E. lucius</u>	2	3	1
Smallmouth bass	<u>Micropterus dolomieu</u>	--	3	13
Largemouth bass	<u>Micropterus salmoides</u>	--	--	62
Walleye	<u>Stizostedion vitreum</u>	31	59	92
Rock bass	<u>Ambloplites rupestris</u>	--	2	3
Redbreast sunfish	<u>Lepomis auritus</u>	--	--	1
Pumpkinseed sunfish	<u>Lepomis gibbosus</u>	1	--	2
Bluegill	<u>Lepomis macrochirus</u>	2	--	5
Black crappie	<u>Pomoxis nigromaculatus</u>	1	1	1
Yellow perch	<u>Perca flavescens</u>	150	--	4
Brown bullhead	<u>Ictalurus nebulosus</u>	372	--	--
Channel catfish	<u>Ictalurus punctatus</u>	--	3	--
Alewife	<u>Alosa pseudoharengus</u>	See footnote for remaining species		
Golden shiner	<u>Notemigonus crysoleucas</u>			
Satinfin shiner	<u>Notropis analostanus</u>			
Spottail shiner	<u>Notropis hudsonius</u>			
Bluntnose minnow	<u>Pimephales notatus</u>			
White sucker	<u>Catostomus commersoni</u>			
American eel	<u>Anguilla rostrata</u>			

Discrete data not collected for non-game fish species, these species were simply recorded  
as having been captured

Source: Modified from reference 29

Table 14. -- Belzville Reservoir, fish tagged through sampling, tag returns by anglers, total angler harvest and population estimates for 1979

Species	Size range (mm)	Tags	Tag returns	Number checked in creel	Population estimate
Walleye	435-660	175	3	20	924
Largemouth bass	225-495	49	5	573	4,783
Smallmouth bass	225-485	12	3	27	91
Chain pickerel	375-546	8	1	27	126
Tiger muskellunge	405-730	3	0	0	--
Brown trout	245-640	3	0	80	--
Rainbow trout	220-445	2	0	0	--
Palomino	235	1	0	0	--
Black crappie	150-249	2	0	67	--
Pumpkinseed	222	1	0	3,654	--
Bluegill	150-195	2	0	418	--
Yellow perch	200-243	4	1	4,677	11,693
Redbreast sunfish	192	1	0	0	--
Rockbass	205	1	0	0	--
Channel catfish	355-400	3	0	209	--

Source: Modified from reference 29

representing 15 species were tagged and released in the lake, tags were returned by anglers only for those 5 species for which 4 or more marked individuals were available in the lake.

The special bass fishing contest resulted in the capture of 8 largemouth bass, including 3 tagged fish. This circumstance indicated a population of only 133 bass longer than 308 mm (12 in). The multiple-capture population estimate for walleyes indicated there were 667 fish longer than 375 mm (15 in) present in the lake. The various estimates of the walleye and bass populations gave disparate results, discussed in the FWS report (op.cit.), viz:

The walleye population estimate from electrofishing shows 1.7 walleye per ha. (0.7 per acre) greater than 375 mm (15 inches) while the estimate from angler harvest showed 2.4 walleye per ha. (1.0 per acre) over 375 mm (15 inches). The angler catch rate of walleye was also slightly higher than the harvest rate suggesting sublegal walleye were caught and released which would support a contention of natural reproduction.

Largemouth bass, the most sought after fish, were estimated at 14.6 per ha. (5.9 per acre) greater than 230 mm (9 inches), and the special fishing event by Carbon County B.A.S.S. produced an estimate of 0.3 bass per ha. (0.1 per acre) over 307 mm (12 inches). The bass population is clearly composed of small individuals at low density.

Scale samples were collected and age determinations and growth information were ascertained for 11 species of fish from Beltzville Lake. According to these data, growth rates for most predator species investigated at Beltzville Lake were slower than corresponding state averages for Pennsylvania. Chain pickerel, and most of the panfish species including pumpkinseed sunfish, rock bass, redbreast sunfish, and yellow

perch, maintain growth rates at Beltzville Lake that exceed state-wide averages (Table 15). The good growth exhibited by sunfish species and the poor growth of larger predator species, such as the tiger muskel-lunge, and the walleye, particularly in the bigger sizes, indicate a lack of suitable prey populations in Beltzville Lake.

#### Angler survey

The angler survey was designed by the PFC and involved a stratified random sampling scheme which essentially divided the year into seasons as well as weekdays vs. weekend days. The procedure used was described by the PFC in their report to SFI (29), viz:

The sample year, March 13, 1979 to March 15, 1980, was divided into four periods: (March/April/May); (June/July/August); (September/October/November/December); and (January/February & part of March when there was ice cover). Each week was divided into a week day strata with weekends and holidays as a separate strata. Each day was divided into three time periods: (600-1200; 1200-1800; 1800-2400). A total of 142 six-hour periods from March 20, 1979 to March 15, 1980 were sampled. No samples were taken between 1800 and 2400 hours while on Eastern Standard Time.

During each sample period, creel clerks made two instantaneous use counts; the count at the beginning and a second at the middle of the period. The counts differentiated shore anglers, boat anglers, total number of power boats, total persons in power boats, total number of non-power boats and total persons in non-power boats. A creel census was conducted for three hours after each count.

Angler interviews were conducted by two or three creel clerks. The interviews included a characterization of the anglers as birth date, zip code of residence, sex, member of sporting group, type of fishing and boating gear owned and used for fishing, and species sought. Angler harvest interviews included time fishing started, time of interview, species caught, number caught, number kept and lengths of individuals kept. The creel clerks attempted to interview a minimum of 10 percent of the observed anglers.

Table 15.- Beltrami Lake, age and growth of eleven important fish species collected by all methods March/April and June, 1970 (sample size shown in last column). Roman numerals indicate number of scale annuli, corresponding to growth years. Comparison with state average shown in last column.

Species	I		II		III		IV		V		VI		VII		VIII		IX	
	mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
<i>Chain Pickerel</i>																		
Beltville	115	(7.1)	282	(11.1)	398	(15.7)	466	(18.3)										
	[19]		[8]		[6]		[2]											
State avg.	165	(6.5)	279	(11.0)	376	(14.8)	443	(17.4)										
<i>Tiger muskellunge</i>																		
Beltville	201	(7.9)	391	(15.4)	504	(19.8)	626	(24.6)										
	[16]		[6]		[3]		[2]											
State avg.	218	(8.6)	503	(19.8)	703	(27.7)	851	(33.5)										
<i>Rock bass</i>																		
Beltville	34	(1.3)	79	(3.1)	147	(5.8)	160	(6.3)	200	(7.9)								
	[4]		[4]		[4]		[2]		[1]									
State avg.	28	(1.1)	77	(3.0)	124	(4.9)	161	(6.3)	189	(7.4)								
<i>Redbreast sunfish</i>																		
Beltville	18	(0.7)	74	(2.9)	118	(4.6)	158	(6.2)	179	(7.0)								
	[11]		[11]		[11]		[1]		[1]									
State avg.	35	(1.4)	70	(2.8)	107	(4.2)	138	(5.4)	149	(5.9)								
<i>Pumpkinseed sunfish</i>																		
Beltville	20	(0.8)	61	(2.4)	100	(3.9)	150	(5.9)	184	(7.2)	208	(8.7)						
	[3]		[3]		[3]		[3]		[3]		[2]		[1]					
State avg.	33	(1.3)	76	(3.0)	117	(4.6)	145	(5.7)	160	(6.3)	170	(6.7)						
<i>Bluegill</i>																		
Beltville	25	(1.0)	50	(2.0)	106	(4.2)	119	(4.7)	143	(5.6)								
	[5]		[5]		[4]		[1]		[1]		[1]		[1]					
State avg.	36	(1.4)	86	(3.4)	130	(5.1)	160	(6.3)	180	(7.1)								
<i>Smallmouth bass</i>																		
Beltville	47	(1.9)	138	(5.4)	193	(7.6)	270	(10.6)	339	(13.3)	387	(15.2)	443	(17.4)	466	(18.3)		
	[15]		[15]		[11]		[11]		[8]		[5]		[2]		[1]			
State avg.	62	(2.7)	152	(6.0)	229	(9.0)	283	(11.1)	325	(12.8)	356	(14.0)	421	(16.6)	454	(17.9)		
<i>Largemouth bass</i>																		
Beltville	60	(2.4)	152	(6.0)	222	(8.7)	277	(10.9)	352	(13.9)	378	(14.9)	413	(16.3)	450	(17.7)	474	(18.7)
	[15]		[54]		[35]		[23]		[10]		[6]		[5]		[3]		[1]	
State avg.	80	(3.1)	180	(7.1)	246	(9.7)	316	(12.4)	358	(14.1)	388	(15.3)	462	(15.8)	471	(16.6)		
<i>Black crappie</i>																		
Beltville	47	(1.9)	136	(5.4)	139	(5.5)												
	[3]		[3]		[1]		[1]											
State avg.	61	(2.4)	145	(5.7)	198	(7.8)												
<i>Yellow perch</i>																		
Beltville	63	(2.5)	112	(5.7)	171	(6.8)	193	(7.6)										
	[22]		[19]		[11]		[7]											
State avg.	64	(2.5)	119	(6.7)	157	(6.7)	193	(7.6)										
<i>Walleye</i>																		
Beltville	117	(4.6)	276	(10.9)	389	(15.1)	447	(17.6)	477	(18.6)	512	(20.7)	513	(20.7)				
	[42]		[42]		[42]		[40]		[27]		[13]		[14]					
State avg.	188	(7.4)	325	(12.8)	409	(16.1)	483	(19.0)	546	(21.5)	596	(21.4)	643	(25.3)				

Source: Reference 29

Angler-use of Beltzville Lake was nearly equally divided between boat and shore fishermen (Table 16). There were an estimated 25,285 angler-trips between March 13, 1979, and March 15, 1980, including 12,243 shore angler-trips (48 %) and 12,815 boat angler-trips (51 %). Shore angling peaked on April 14, 1979, the opening day of the trout season; boat angling peaked on June 6, 1979, the opening day of the bass season. Ice fishermen made only 221 trips (1 %) during the relatively mild winter of 1979-80.

Separate estimates were developed for total boating use of the lake. Pertinent discussion from the 1980 PFC report is as follows:

The 10,332 boats using Beltzville Reservoir amounted to 26.9 per ha. (10.9 per acre) for the year. Boating use from June through August amounted to 64 percent of the total. The peak use was on June 23, 1979 when 118 boats or one boat per 3.25 ha. (one per 5 acres) were observed. Power boats were estimated to comprise more than 91 percent of all boats used on the reservoir.

The use of boats for angling and non-angling was nearly equal. There were 14,479 non-anglers or 53 percent and 12,815 anglers or 47 percent. The average number of persons per boat was 2.5.

Anglers were generally local residents, with 85 percent residing within 50 km (31 mi) of the lake. Few women fished at Beltzville Lake (99.5 percent male). A significant proportion of the anglers (48 percent) were members of some organized sporting club.

It is interesting to compare the PFC estimate of 25,285 angler-trips during the 1979 angling season (actually, mid-March 1979 to mid-March 1980) to estimates of annual angler-visits developed by the PBSP and reported by the CE (Table 17). The PBSP/CE estimate of 112,675 angler-

Table 16. -- Estimated total angler-use by weekday and weekend at Belzville Lake from March 13, 1979 to March 15, 1980

Type of angler	Type of day	Season				Total	95% confidence interval
		Mar-May	Jun-Aug	Sept-Dec	Jan-Mar		
Shore anglers	Weekday	4,032	2,560	596		7,188	(5,394, 8,968)
	Weekend	2,360	2,214	481		5,055	(3,414, 6,691)
Boat anglers	Weekday	1,120	3,904	1,020		6,044	(5,062, 7,117)
	Weekend	900	4,428	1,443		6,771	(4,996, 8,546)
Ice anglers	Weekday				53	53	(49, 57)
	Weekend				168	168	(150, 186)
Total anglers	Weekday	5,152	6,464	1,615*	53	13,284	(13,035, 13,437)
	Weekend	3,240*	6,669*	1,924	168	12,001	(11,734, 12,268)
Grand total	--	8,392	13,133	3,539	221	25,285	(24,977, 25,593)

Source: From reference 29

\* Minor addition errors identified but not corrected, totals would remain essentially the same.

**Table 17. -- Angler-visitation estimates reported by Pennsylvania Bureau of State Parks (PBSP), Army Corps of Engineers (CE) and Pennsylvania Fish Commission (PFC) for Beltzville Lake**

Year	Reporting agency	
	PBSP/CE	PFC
1972	38,936	--
1973	76,089	--
1974	123,579	--
1975	126,248	--
1976	126,255	--
1977	125,040	--
1978	121,205	--
1979	112,675	25,285

visits for 1979 is 4.5 times greater than the PFC figure.

Target species sought were the larger game fish species, described in the 1980 PFC report, as follows:

Bass were sought by 27.8 percent of the 727 anglers providing useable responses from both surveys. The second most frequently sought species were catfish (20.5 %) followed by pickerel and muskellunge (15.4 %); trout (14.7 %); walleye (9.6 %), sunfish (9.1 %), crappie (1.9 %) and perch (1.0 %). When anglers indicated more than one species sought it was walleye for 25 % of the 186 responses.

Angling success at Beltzville Lake was relatively poor, with less than 0.25 fish harvested per angler-hour (Table 18). Bullhead catfish were harvested more frequently than any other fish. On the average, one bass (largemouths and smallmouths combined) was harvested for every 250 angler-hours of fishing effort. One walleye was harvested for every 1,000 hours of angling effort.

Estimates of total harvest were not developed during the PFC's study of the Beltzville fishery. Reported harvest data were computed based upon the effort and catch of anglers at the time they were interviewed by the roving creel clerks. Thus, completed trips were seldom included in the survey. In fact, the average amount of fishing effort reported at the time of interviews barely exceeded two hours (2.06 hrs). To compute the total harvest from Beltzville Lake, an estimate of total angler hours would be necessary to employ in relation to the harvest rate data that were acquired.

In the absence of completed trip-length information, the present report has employed average completed trip-length data which were acquired during a 1980 creel survey at Justus Lake, Venango County, PA. Complete and

Table 18. -- Harvest-rates (fish per hour)  
for all fishermen interviewed during  
1979-80 creel survey at Beltzville Lake

Estimate	Harvest per hour
Brown bullhead/hour	0.083
Pumpkinseed/hour	0.058
Yellow perch/hour	0.041
Bluegill/hour	0.026
Channel catfish/hour	0.013
Largemouth bass/hour	0.003
Black crappie/hour	0.003
Smallmouth bass/hour	0.001
Walleye/hour	0.001
Total catch/hour	0.229

Source: Modified from reference 29

incomplete trips were discriminated during the Justus Lake survey. Completed boat angling trips there averaged 3.93 hours, and completed shore angling trips there averaged 2.65 hours. Total harvest estimates for Beltsville were then computed by multiplying the number of angler-trips at Beltsville X the average length of completed angler-trips at Justus Lake X the average harvest rates (number caught/hour) for each species at Beltsville Lake. Weight of fish harvested was computed by multiplying the number of each species caught by size groups, by the mean weight for those size groups as reflected in the net and electrofishing data.

Brown bullhead dominated the harvest both by number and by weight creeled (36.0 and 46.4 percent, respectively). A total of 18,356 fish or 47.7/ha (19.5/ac) weighing 3,862 kg (8,514 lbs) or 10.4 kg/ha (9.0 lbs/ac) were harvested (Table 19). Predator species such as largemouth bass, smallmouth bass, and walleyes were poorly represented in the harvest. In combination, these four species contributed only 0.8 fish/ha (0.5/ac). It is perhaps noteworthy that no muskellunge were recorded as caught.

The tailrace below Beltsville is managed as a catchable trout fishery. Quantification of the angler-use of this resource was an objective of the study conducted by the PFC. The first progress (quarterly) report submitted to the Contractor by the PFC stated that the tailrace was in process of being surveyed. Shortly thereafter, the PFC notified the Contractor that, for reasons not clearly understood, survey personnel

Table 19 -- Estimated harvest of game fish at Beltrami Lake, March 15, 1979 to March 15, 1980

Species	Number				Weight				
	Total number	No./ha	No./ac	% of total	Kg	Lbs	Kg/ha	Lbs/ac	% of total
Brown bullhead	6,615	17.3	7.0	36.0	1,792	3,951	4.7	4.7	46.4
Pumpkinseed sunfish	6,568	11.9	4.8	24.7	563	1,241	1.5	1.3	14.6
Channel catfish	1,074	2.8	1.1	5.9	454	1,001	1.3	1.1	11.8
Yellow perch	3,390	8.9	3.6	18.4	268	596	0.7	0.6	6.9
Bluegill	2,067	5.4	2.2	11.2	256	564	0.7	0.6	6.6
Largemouth bass	248	0.6	0.3	1.4	173	392	0.5	0.4	4.6
Walleye	83	0.1	0.1	0.5	175	386	0.5	0.4	4.5
Black crappie	249	0.6	0.3	1.4	100	221	0.3	0.2	2.6
Smallmouth bass	83	0.1	0.1	0.5	78	172	0.2	0.2	2.0
Total	18,356	47.7	19.7	100	3,662	8,514	10.4	9.0	100

had failed to obtain the regularly-scheduled angler counts for the tailrace trout fishery. Only one count was made, on April 14, 1979, the opening day of the trout season. The PFC reported the oversight as follows, (R.L. Hoopes, Warmwater Unit Leader, PFC, pers. comm., 1980):

The catchable trout fishery [for the report period July 1 - September 30, 1979] in the tailrace was nearly non-existent until July 21, 1979, when Beltzville Rod & Gun Club stocked 500 brown trout. This resulted in renewed interest in the tailrace fishery. It was discovered during the second quarter that use counts were not recorded on the tailwater fishery after the first two days of trout season. This will severely limit the analysis of the tailwater fishery. It will not affect analysis on the reservoir fishery. The problem was rectified when discovered.

As noted by the PFC, counts of anglers in the tailrace were reinstated on July 28, 1979. These data indicated that the tailrace supported very light fishing pressure from that juncture until the end of the study in mid-March, 1980. Anglers were present in the tailrace area on 28 out of the approximately 85 counts made during this 7½-month period. Except for opening days, the maximum count occurred on July 28, 1979, (8 anglers) and the average (including 0 counts) was just under 1 angler per count. On opening day, 350 anglers were counted using the tailrace. The count was made at 9:00 AM on April 14, 1979, one hour after the official opening of the trout season.

The apparently intense use during the early spring was directly related to the trout stocking program of the PFC. A pre-season stocking of 2,500 brown trout and 1,500 rainbow trout was made on March 7, 1979. A second plant of 1,250 brown trout and 1,250 rainbow trout was made four

days after opening day (i.e., April 19, 1979). The Beltzville Rod and Gun Club made one stocking of 500 brown trout on July 21, 1979, as noted by the PFC (op.cit.). In total, Pohopoco Creek received 7,000 catchable trout during 1979. The total amount of fishing supported by the catchable trout may have made a significant contribution to the total recreational angling associated with the Beltzville project. It is unfortunate that no estimate of this use could be developed.

Fishery Resources -- Discussion of Planning Input

The prime planning aid relating to fishery resources of the Beltzville Lake project was prepared by the PFC and FWS in 1964. The 1964 report followed an earlier (1960) reconnaissance-quality evaluation of a total of 21 projects proposed for the Delaware River Basin. The 1964 report contained use predictions for the reservoir and remaining section of Pohopoco Creek below the dam. The report also contained 9 recommended actions for maximizing fish and wildlife values associated with the project. An evaluation of the adequacy of the fishery-related planning input requires examination of the efficacy of these planning recommendations.

The first recommendation specified a certain water-level manipulation strategy. Carp were expected to be serious competitors with the desirable game fish species at Beltzville. To alleviate or control the carp population, the FWS/PFC report requested spring water-level reductions to strand and dessicate carp eggs. Lowering of the lake was to be accomplished upon request from the PFC. This particular recommendation remains untested, because the PFC has not requested such lowerings to date. Although carp may inhabit Beltzville Lake, no specimens were captured during the extensive netting and electrofishing in 1979. Certainly, contrary to pre-impoundment expectations, carp have not become a nuisance species at Beltzville Lake. The surface temperature of Beltzville Lake normally reaches 15.5 C (60 F), the temperature at which carp spawning begins, in May. The average water-level fluctuation in May has been 0.8 m (2.5 ft). However, the normal lowering of

the lake during this period has been too slow and too little to have prevented carp spawning.

According to the PFC (Rickalon Hoopes, Warmwater Unit Leader, pers. comm., 1981), significant infestations of Beltzville Lake by carp are not deemed likely. This current expectation derives from the unfavorable character of the littoral zone around the impoundment's perimeter.

The second fishery-related recommendation in the 1964 FWS report, a request for construction of 95 log fish attractors, was withdrawn at a later date. The construction agency completely cleared the basin of Beltzville Lake of all timber and brush prior to impoundment. The structures were requested to effect partial replacement of the fish-concentrating characteristics of inundated cover. Although frequently encountered in the planning files for projects of similar purpose located elsewhere, no apparent consideration was given by the affected agencies to the preservation of selected areas of standing timber within the lake basin. In 1968, updated engineering data more clearly identified water-level fluctuation inherent in withdrawals from Beltzville for flow augmentation and potable supplies. Taking into account the anticipated late summer water-level reduction of 4.6 m (15 ft), the necessity to maintain the fish attractors under at least 1.2 m (4 ft) of water during the boating season was deemed prohibitive of their construction. Moreover, the expected water quality at 5.8 m (19 ft) of depth was thought to be inadequate to support fish life near the devices. Actual post-impoundment experience has been that water levels

have dropped by 4.6 m (15 ft) only once since the lake was filled in the fall of 1980.

The decision by the PFC and FWS, as a safety measure, to withdraw their request for fish attractors was an unfortunate major concession to boating usage of Beltzville Lake. This circumstance is emphasized by the eventual designation, as "no wake" zones, of the 4 large coves on the north side of Beltzville Lake and the entire upper end of the lake. Carefully located and marked fish attractors constructed at proper depths within the coves and upper end could significantly enhance the sport fishery at Beltzville without constituting undue risk to boaters.

Zoning of the lake was recommended in the 1964 report although, at the time, enforcement of such a regulation appeared troublesome to the PFC because it lacked zoning authority. Instead of a specific zoning plan, the 1964 FWS/PFC report recommended continued cooperative consideration and eventual preparation of an acceptable plan. Zoning was accomplished later, as noted above. The currently enforced plan limits boats to "no wake" speeds on most major coves and on the narrow upper arms of Beltzville Lake.

Other FWS/PFC recommendations addressed standard institutional practices, all of which have been satisfactorily attained. They included the recommendation that project waters be made available to the PFC for fishery management purposes, that two access sites on the reservoir and one on the tailrace be developed, and that fishing be allowed on project waters. A final recommendation sought future project modifications as

required to maximize over-all project benefits. No such modifications have been proposed to the present (1980).

The 1964 FWS report accepted the CE's stated plan to maintain a minimum flow release of 35 cfs from Beltzville Lake to protect the instream fishery in Pohopoco Creek and provide improved water quality downstream in the Lehigh River. The conservation agencies emphasized the desirability of maintaining the temperatures of the released water below 21 C (70 F). For the most part, both temperature and flow agreements have been maintained by the CE's operational staff at the Beltzville project. Pohopoco Creek, below the project, continues to be managed by the PFC as a put-and-take trout fishery, as was the case prior to project construction.

It is particularly noteworthy that the waters released from Beltzville Lake would have been nearly devoid of oxygen during August, September, and early October in 5 out of 6 years of record (1975-1980) if a bottom-draw outlet had been installed as the FWS had requested. The multi-port selective intake tower was installed by the CE to meet water quality criteria established by the Public Health Service late in the planning process. This facility enables the mixing of warm well-oxygenated water with cold oxygen-deficient water, thereby meeting water quality criteria suitable for a healthy fish community. The lower section of the Pohopoco Creek, below the dam site, was considered the poorest section of the stream prior to lake construction. Post-impoundment conditions may well be better than pre-impoundment conditions as a result of the temperature

and flow management made possible by Beltzville Lake. On the other hand, the lake flooded the best portion of Pohopoco Creek trout fishery, which was a clear loss.

In summary, construction and operational actions proposed by the construction agency in order to benefit (largely indirectly) production and use of the Beltzville Lake project's recreational fishery have been successfully implemented in the main. These initiatives included maintaining a relatively stable reservoir water level during the recreational season, zoning the lake for competitive uses, and releasing a minimum downstream flow of 35 cfs.

Neither of the specific fishery management recommendations generated by the conservation agencies were implemented at Beltzville Lake. The recommended water-level manipulation for carp control proved unnecessary. The recommendation to install fish attractors was withdrawn. The FWS's cold-water discharge recommendation was accommodated although the actual release levels were necessarily contrary to FWS requests.

Project impacts were evaluated by the FWS/PFC in their 1964 report, as was customary, in terms of the number of angler-days which would be supported on the lake and remaining stream habitat (Table 20). These data were supplemented by newly-acquired estimates of fishing effort developed in 1979-80. Total angler-use of the project was predicted to be 33,000 man-days, including insignificant use of the tailrace. The PFC survey of Beltzville Lake angling indicated that 25,285 trips were made to the lake between March 15, 1979, and March 15, 1980. This level of

Table 20. -- Predicted angler use of Beltzville Lake and Pohopoco Creek under with-and-without project conditions; predictions generated by FWS

Location	Without project	With project	
		Predicted (1964)	Actual (1979-1980)
Reservoir site	4,800	33,000	25,285
Pohopoco Creek below Beltzville Dam	3,000	Insignificant	Unknown but significant
Total	7,800	33,000	25,285+

use was only 22 percent of the angling activity reported by local administrative agencies, including the CE.

Unfortunately, use estimates for the tailwater fishery were not generated by the PFC's survey. Angler counts on opening day of trout season reflected intensive early season use (350 anglers counted). This heavy usage is directly associated with PFC plants of catchable trout in the tailwater and is normally greatly reduced by Memorial Day. It would seem likely, if the tailwater use could be added to the angler-use estimated for the lake (25,285 angler-trips), that the FWS's prediction of 33,000 angler-trips would be reasonably accurate.

Fish production at Beltzville, as elsewhere, is directly related to the availability of primary nutrients, specifically nitrogen and phosphorous. The complex food chain links the ultimate quantity of available fish life (and, thus, angler harvest) to these elemental constituents by way of the higher invertebrate and plankton communities. The basic fertility of Beltzville Lake is rather low (total hardness of 6 to 24 ppm). This factor may provide excellent conditions for swimming and water supply uses, but it is directly associated with the fact that a rather scant fish population occupies the lake.

Fish species which rely upon the lower trophic levels for their sustenance supported the majority of the harvest at Beltzville Lake. Four such species (brown bullhead, pumpkinseed sunfish, and bluegill, and yellow perch) combined to provide 90 percent of the total harvest by number. Harvest of higher trophic-level predators combined to contri-

bute only 9 percent. This last category included channel catfish (truly predatory only in the larger sizes) as well as largemouth bass, walleyes, black crappie, and smallmouth bass. The estimate for total harvest during the 1979-80 fishing year was less than 48 fish weighing 10.4 kg per ha (20 fish at 9 lbs/sc).

Above-average growth rates were common among prey species except bluegill. Below-average growth was exhibited by most predator species. Both conditions are typically characteristic indicators of a fish community dominated by predators.

## SUMMARY

Beltzville Dam is located in Carbon County, Pennsylvania, on Pohopoco Creek, approximately 8.4 km (5.2 mi) above its confluence with the Lehigh River. The drainage basin covers 284 km<sup>2</sup> (111 mi<sup>2</sup>) and the portion located above Beltzville Dam covers approximately 242 km<sup>2</sup> (93 mi<sup>2</sup>). Soils in the drainage yield infertile waters.

The Beltzville project was authorized in the Flood Control Act of 1962, the first unit of the comprehensive plan for Delaware River Basin water resource development. The primary project purposes are flood control and water supply. The lake covers 383 ha (947 ac) at recreational pool elevation 191.4 m (628 ft) mean sea level (msl). The maximum flood control pool level is 198.4 m (651 ft) msl which includes a surface area of 571 ha (1,411 ac). The outlet works consists of a control tower and multi-level intake structures. This feature, designed to mix discharge water selectively, was the first such facility built by the CE.

The U.S. Army Corps of Engineers (CE) owns 1,496 ha (3,695 ac) at the Beltzville Lake project. The Pennsylvania Bureau of Parks (PBP) leases 1,217 ha (3,007 ac) of lands and waters. Additionally, 171 ha (422 ac) of lands are leased to the Pennsylvania Game Commission (PGC) for wildlife management purposes. The CE has retained 108 ha (266 ac) for the dam, administration building, and operational appurtenances.

Most of the fish-and-wildlife-related planning for the Beltzville project occurred over the three-year period, 1961-1964. The original wildlife planning report prepared by the FWS in 1961 indicated that fed-

eral acquisition of an area roughly equivalent to the area of lands to be permanently flooded, and opening of these lands to public hunting, would recover all project-associated wildlife losses, in terms of hunter use, at the Beltzville project. The FWS also suggested that intense management of a 56-ha (138-ac) area would nearly double the with-project wildlife resource values.

Shortly thereafter, the FWS indicated that mitigation of wildlife-associated damages at Beltzville would require an initial investment of \$5,600 and an annual OM&R cost of \$2,200 on a portion of project lands. The final FWS report, released in 1964, reiterated this later position, indicating that inundation of 384 ha (950 ac) would result in a loss of 200 man-days of hunting. The report therefore recommended the intense management of 121 ha (300 ac) of project land at a cost of \$5,600 for initial development and \$2,200 O&M annually for a period of five years, for a total five-year cost of \$16,600. The FWS further recommended licensing the 121 ha (300 ac) of project lands to the PGC for wildlife management purposes. The third and final FWS recommendation was that public hunting be allowed on the remaining project lands to the extent consistent with other project purposes.

The CE sought additional information from the conservation agencies, regarding the development features planned for the mitigation lands; no such plans were forthcoming. Instead, the FWS notified the CE that no specific plans had been developed for the requested funding and that the \$16,600 request was based on prior experiences at similar facil-

ties. In the final analysis, the desired project lands were licensed to the PGC for wildlife management; however, development and operation have been totally at state expense.

The PGC has obtained, on the average, \$1,773 worth of grain annually from sharecroppers using the licensed Beltzville project lands. The \$1,773 derived is used by the PGC to rear pen-raised game birds, but that revenue falls far short of putting the PGC's Beltzville management program on a pay-as-you-go basis. The PGC is able, using the limited resources generated at the Beltzville licensed lands (sharecropping agreements) plus an average annual subsidy of \$14,000 from other sources, to provide many times more hunting use on the Beltzville project lands than had existed on the same lands prior to project construction, or would be likely to exist in the absence of the project.

Current use estimates, though far from perfectly acquired, reflect hunter-use of project lands at around 20,000 trips annually, a level approximately 25 times greater than pre-project levels. Heavy hunting use of project lands, even of those lands where wildlife resources are essentially unmanaged -- i.e., the largely forested PBSP licensed lands, certainly belie the FWS's 1964 contention that mere public acquisition of private lands, and opening these lands to public hunting, would not generate greater hunting activity.

The low priority accorded by the CE's Philadelphia District to wildlife mitigation matters at Beltzville is abundantly evident from the available records. Each time the FWS sought specific land acquisition

or land allocation data upon which to base their mitigation recommendations, the development agency responded only in the most general of terms. The short lead time provided by the CE for requested FWS planning reports constituted yet another reflection of the minor importance attached by the construction agency to wildlife impacts associated with the Beltzville project. At no point did the construction agency or project beneficiaries incur additional costs related to losses of wildlife resources associated with the permanent inundation of 384 ha (950 ac) of habitat on Pohopoco Creek.

The prime planning aid relating to fishery resources was prepared by the PFC and FWS in 1964. The 1964 report presented angler-use predictions for the proposed lake and 9 recommended construction and operational actions for maximizing fishery values.

The conservation agencies expected carp to be a serious problem at Beltzville and requested spring water-level reductions to retard carp reproduction. Although carp may inhabit Beltzville Lake, no specimens were captured during extensive netting and electrofishing in 1979. Moreover, contrary to pre-impoundment expectations, carp have not become a nuisance species at Beltzville Lake.

No apparent effort was made by the affected agencies to preserve selected areas of standing timber within the lake basin. The construction agency completely cleared the basin of Beltzville Lake of all timber and brush prior to impoundment. The conservation agencies requested construction of 95 fish attractors as partial replacement of the fish

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concentrating characteristics of inundated cover. Plans to increase water drawdown during summer indicated to the conservation agencies that the previously proposed structures would, if built, become hazardous to boating. Consequently, the recommendation was withdrawn.

In retrospect, carefully located and well marked fish attractors, sited within the coves and upper end of Beltzville Lake, now designated as "no wake" boating zones, could significantly enhance the sport fishery at Beltzville without offering undue risk to boaters. Renewed consideration should be given to this valuable management tool.

The issue of lake zoning was initially raised by the CE. Zoning was discussed in the 1964 report to the CE. Though agreeing in principal, the report omitted a specific zoning plan due to enforcement considerations. As indicated, "no wake" zoning was eventually adopted at Beltzville Lake.

Other recommendations provided that project waters be made available to the PGC for fishery management, that fishing be allowed on project waters, and that two access sites on the reservoir and one on the tailrace be developed. These actions have all been implemented. Consideration of project modifications in the future, as required to maximize over-all project benefits, was also specified. No such modifications have been proposed to the present (1980).

The 1964 FWS report accepted the CE's stated plan to maintain a minimum flow release of 35 cfs from Beltzville Lake, and emphasized the desir-

ability of maintaining the released water temperatures below 21 C (70 F). Temperature and flow agreements have generally been maintained by the CE's operational staff at the Beltzville project. Temperature and oxygen data clearly document that waters released from Beltzville Lake would have been nearly devoid of oxygen during August, September, and early October had a bottom-draw outlet been installed as the FWS had requested.

The outlet tower, with its multi-level intake ports (the first such structures built by the CE) allows mixing well-oxygenated warm surface water with oxygen-deficient cold water, thereby meeting water quality criteria established late in the planning process by the Public Health Service. Pohopoco Creek, below the dam site, was considered the poorest section of trout habitat on the stream prior to lake construction. Conditions there may well have become more favorable for trout as a result of the temperature and flow management made possible by Beltzville Lake.

Total angler-use of the project was predicted to average 33,000 man-days annually, including insignificant use of the tailrace. The PFC survey of Beltzville Lake angling indicated that 25,285 trips were made to the lake between March 15, 1979, and March 15, 1980. Unfortunately, use estimates for the tailwater fishery could not be generated by the PFC's survey. Nevertheless, it appears likely, if tailwater-use could be added to lake-use (25,285 angler trips), that the FWS's prediction of 33,000 angler-trips would be reasonably accurate.

Basic fertility of Beltzville Lake is rather poor, the measured total hardness ranging from 6 to 24 ppm. The lake's basic infertility accounts directly for the relatively scant fish population being supported by the lake. Estimated total harvest during 1979-1980 was less than 48 fish weighing 10.4 kg per ha (20 fish weighing 9 lbs per ac). Above-average growth rates were common for prey species except bluegill. Below-average growth was exhibited by most predator species. Both conditions are typically characteristic indicators of a community dominated by predators.

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